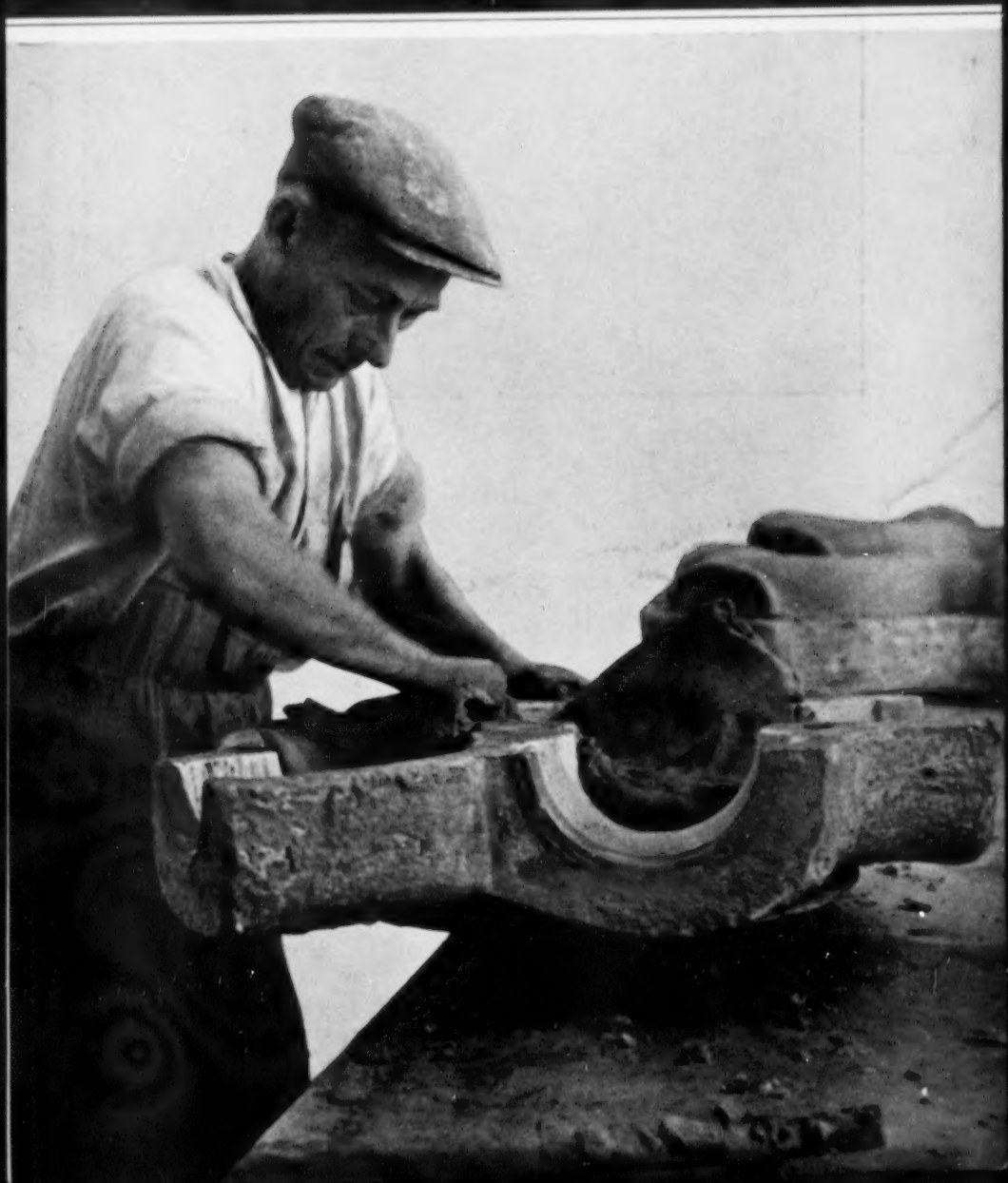
CERAMICS



EVERYONE connected with the Pottery Industry is familiar with the usual method of running frit, as depicted above, and all will agree that the process "is out of step" with modern developments within the industry. As specialists in the manufacture of lead and borax frits we have developed a completely new type of furnace, continuous in operation, which is more efficient and yields a uniform product of improved quality. Besides supplying our well-known standard frits, we can undertake the production of any type of frit to user's specification. On receipt of details we shall be pleased to submit a counter sample and quote for your requirements.

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Ceramics

VOL. II SEPTEMBER, 1950 NO. 19

Real Co-operation!

TECHNICAL education is forefront in the minds of all who look to the future of industrial Britain. Unfortunately the very word is so often misinterpreted

Production and more of it, are the watch words of both political parties—but what steps are taken to try and pass on general knowledge of technology to the fitters, turners and factory workers of tomorrow?

Latin and Classics are being taught today in an extent far above their real importance!

Yet the industrial worker entering the factory at the age of 15—upon whom we all live—has had precious little done for him by the Welfare State!

In our humble way we try to make up for this fatal missing link. CERAMICS began because we thought there was need for a live journal covering the ceramics field—not for trained scientists and academic minds and not as a kind of ceramic tit-bit for the workers; but something which was real, practical and related to production and production problems.

In 12 months the subscription response has been remarkable, proving that there was a need for something like CERAMICS. The standard, ability, and skill of CERAMICS correspondents is high indeed.

Yet with all the ballyhoo in the world we could not sell a single copy of CERAMICS at less than 15s. if it carried no advertising!

Thus the publisher and the advertiser together subsidise the enterprise of deceminating technical knowledge.

Having been in business just over a year we would like to thank those advertisers who have helped us in this mission, which is also our business, and we would like to say that between us we have started something for the industry which will live for many a long day!

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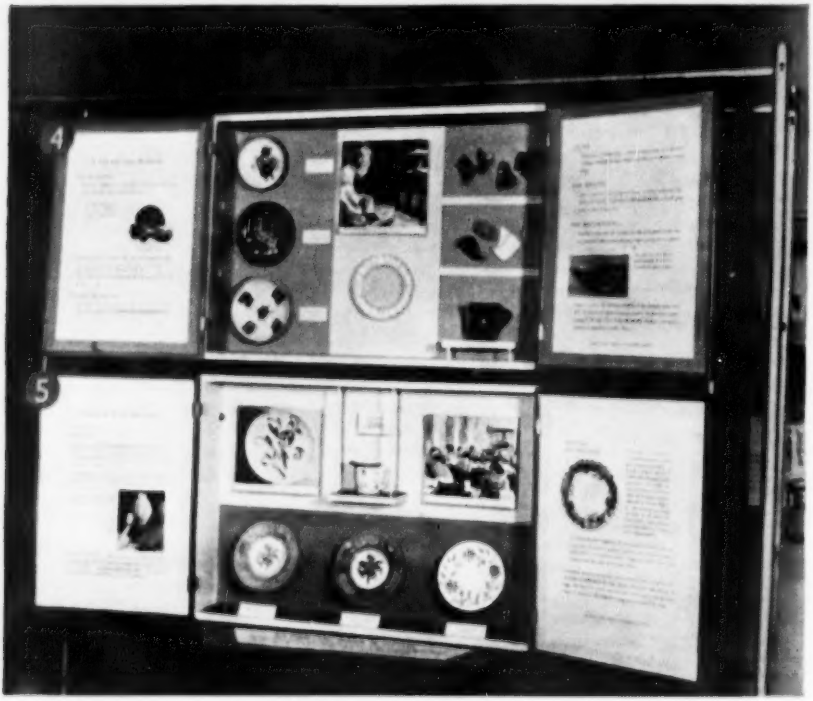
An Impressive Exhibition ?

• *by Argus* •

TROUBLE, trouble! . . . CERAMICS has incurred the displeasure of that august body called the Council of Industrial Design!

Maybe it will be recalled that in July, under the title "An Unimpressive Exhibition," an eye-witness account was given of a travelling pottery exhibition. This exhibition has been the substance of several advanced notices by the Council, informing the public where and when it could be seen. The CERAMICS reporter who went to see it was not impressed! In July, CERAMICS said:

"The Council of Industrial Design whilst setting out with the ostensible motive of making the consumer design-conscious and appreciative of the 'better things' in life, have rather placed themselves in the position of Cæsar's wife. And Cæsar's wife fell from grace in no less a town than Darlington! CERAMICS heard from the Council that there was a travelling pottery display which would be in the local museum. We arranged to see it. In the words of an eye witness—'A more pitiful collection I have never witnessed.' It was displayed in a very small gallery, the door of which bore a crude notice, written in Indian ink on a



. . . self explanatory to anyone who can read . . .

crumpled piece of brown paper. The collection itself consisted of six cases, each containing an average of half-a-dozen pieces bearing typescript notes which were themselves examples of unimaginative advertising at its worst. The resident attendant who displayed no enthusiasm for the exhibition, reluctantly offered for sale booklets and pamphlets on Industrial Design in practically every field except pottery whilst venturing the opinion 'You'd have thought they'd have sent a chap along to explain things!'

"This is a mobile exhibition doing the rounds of the various towns. Our eye witness said that 'to send such a miserable collection to Darlington, a spot where a large percentage of the inhabitants know, appreciate *and* collect good ware, is a most unfortunate move.

"Must it be pointed out again that the cultural lead of the provinces in the realms of literature, art and craft is high indeed by comparison with a London suburb! The latter is used to ballyhoo but the former takes to it unkindly.

"If this is a true story—and our eye witness is a reliable one—it is suggested that the Council withdraw this travelling exhibition at the earliest possible moment and if they wish to stage it again, seek help and advice from those who know the pottery trade."

The Council responded in no uncertain manner, and here is what they said:

The Council of Industrial Design
Tilbury House, Petty France, S.W.1.
15th August, 1950.

DEAR SIR,

An Unimpressive Exhibition

I cannot let your vigorous and sweeping condemnation of this Council's small portable exhibit of pottery design and production pass unanswered, for clearly your "eye witness" must have been under a misapprehension about the scale of the display before going along to see it. This exhibit was designed in the first place for touring to schools but the demand for the six sets was so great that the Council decided to offer them to museums and galleries so that more than one school in each neighbourhood could have the benefit of them.

Each set consists of six small boxes. The manufacture and design of pottery is described by example and explanatory text, the various processes being illustrated in turn, starting from the raw materials in the first box. The display is not intended to be comprehensive, nor to give a picture of the design standard of the industry today; the exhibit is purely educational and we have, till now, had no reason to doubt its value from this point of view. The comments we have received from schools and museum authorities are sufficient evidence that the display is doing the job for which it was designed. These comments are, of course, open to your inspection.

Your reporter is on less sure ground when he condemns the display and the "typescript notes." The boxes were designed and made by Cockade Ltd., one of the acknowledged leaders in the display and exhibition business. The "typescript notes" are in fact typeset in Gill Perpetua, one of the most legible and elegant faces designed in this century. The layout was designed for clarity and continuity of reading and not as a piece of "imaginative advertising"—whatever your informant means by that expression.

Your editorial comment further suggests that we prepared this display without consulting "those who know the pottery trade." In fact we were advised throughout by Mr. Bernard Hollowood, Editor of your contemporary, *Pottery and Glass*," by Mr. Lucien Myers, formerly Assistant Editor of the same journal and now managing director of Carter, Stabler and Adams Ltd., and by Miss Dora Billington, A.R.C.A., Instructor in charge of Pottery at the Central School of Arts and Crafts, Southampton Row, W.C.1, and President of the Arts and Crafts Exhibition Society.

The following firms, moreover, co-operated by supplying the necessary exhibits from the raw materials, through biscuit to glazed and decorated ware: A. W. Buchan and Co. Ltd., Carter, Stabler and Adams Ltd., Susie Cooper Pottery Ltd., W. T. Copeland and Sons Ltd., Doulton and Co. Ltd., Leach Pottery, Mintons Ltd., Moorcroft Ltd., Old Hampstead Pottery Co., Pountney and Co. Ltd., Tuscan China, Henry Watson's Potteries Ltd., Josiah Wedgwood and Sons Ltd., Worcester Royal Porcelain Co. Ltd.

In fairness to those schools and galleries which have displayed these boxes in an endeavour to create informed interest in your industry, I must ask you to publish this letter together with this photograph, which shows two of the six boxes. I think it should be clear, even from a photograph, that the display is self explanatory to anyone who can read and does not call for "a chap to be sent along to explain things."

Yours faithfully

(signed) Paul Reilly,
Chief Information Officer.

There you have it—the opinion of

those who are circulating this cultural exhibition and one who went along as a member of the public interested in pottery!

It is accepted that the exhibit was designed to tour schools—so that it was an exhibit to arouse interest by the adolescent in the pottery craft. This is in itself a most worthy consideration. However, it escapes its environment in the school and is exhibited to a grown-up public. Surely it is in that transition that, controversy might be pursued. Indeed the cynic might say that the Council are treating the public like schoolboys, or, perhaps the schoolboys like adults! A cultural exhibit primarily designed for educating—a horrid word—the adolescent is not necessarily that which is attractive or of interest to the general public. The schoolboy is interested primarily in things—how they are made, what they are, and how they work. His interest in a radio set is riveted upon circuits, transformers and the like. He gathers a tremendous fund of information on gas turbine engines—how they work, what they are.

Adult Approach

But the adult public has a different approach. Age has mellowed their curiosity to the extent of utilitarianism. Their interest in a radio set is the smallest number of knobs, and they couldn't care less about the intricacies of the innards, so long as it works every day and every night. Likewise with pottery; public interest is not in the raw materials, the processing and so on, except as an ancillary to the goods themselves. To see and feel the best examples of the pottery art is to them the importance of the pottery industry.

One feels regretful in having to point this out to an organisation such as the Council of Industrial Design, for it seems clear from their letter that an original concept has been broadened. They start with a cultural exhibit for schools and end by using the exhibit for general exhibition to the public to stimulate interest in ceramics. No doubt this departure from the particular to the general was thoughtlessly incurred. But the criticisms of the CERAMICS observer were based not upon a school exhibit but on one shown to the general public.

Release Decorative Ware

The pottery interests of Britain are best served by showing the best examples of pottery to the British public, for that is a little luxury from which they have been long starved. The provincial housewife will not become enamoured with the art of the potter when it is presented in real life as thick white ware!

Although this may be outside the province of the Council of Industrial Design, yet if their urge compels them to arrousing a cultural interest of the lay public in pottery, a suggestion from them to their sponsors —H. M. Government—that Britain is forgetting that British pottery is superlative, might cause the clam-like fist of the Board of Trade to relax and allow some examples of the contemporary decorative pottery art to be on sale in British shops.

There is always danger when one sets up an arbitrary "Ministry of Culture." It can make mistakes of the most elementary kind and become too sensitive to criticism. Any educationalist will agree, it is felt sure that the means of arousing interest of the adult public and the adolescent schoolboy are distinctly different. The latter has the world to discover, whilst the former has made his discovery and found that the dream world of youth is a very evanescent thing in the stark business of earning ones living.

The Council gave away their case when they said "this exhibit was designed in the first place for touring the schools . . . " That is not the setting in which our eye witness was invited to see it.

But, Mr. Reilly, it was not the

"eye witness" who called for "a chap to be sent along to explain things." It was the attendant in charge!

And in passing, the phrase "I must ask you to publish this letter together with this photograph" . . . well Mr. Reilly that "must" nearly caused the Editor to consign to the W.P.B. But he was talked round when it was explained that what was really meant was "I hope you will be good enough to . . ." He agreed that CERAMICS must not be hypersensitive!

Everyone Suddenly Bursts Out Singing

And just to drive in my point about babes, sucklings, grown-ups and the design propaganda of the Council of Industrial Design—here is an extract from their September *Design Newsletter*.

"Everyone, that is to say at Somerford Hall Camp School, Congleton, Cheshire where two members of the staff have written works and music for 'My Shopping Song' in which each verse asks a question pertinent to the appreciation of good design.

"The idea seems to work; a visitor, hearing that design appreciation was one of the subjects on the curriculum, expressed utter disbelief in the possibility of inculcating the first principles of good taste or an elementary understanding of good design during the three months the children have at Congleton. The member of the staff with whom he was talking turned to a child and asked: 'How would you choose something you wanted to buy?' Pat came the answer: 'I should ask myself the five questions in the song—Does it do the job? Does this thing look well? Is it well made? Does it clean with ease? Is it right for me?' "

But Mama who has grown up asks a sixth—and most important question, "Can I afford it at that price?" See what I mean about the childs and the adults approach?

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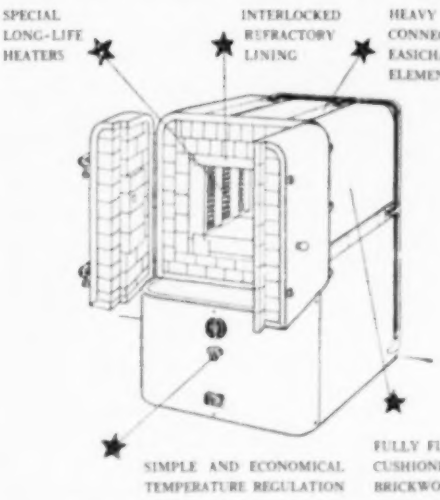
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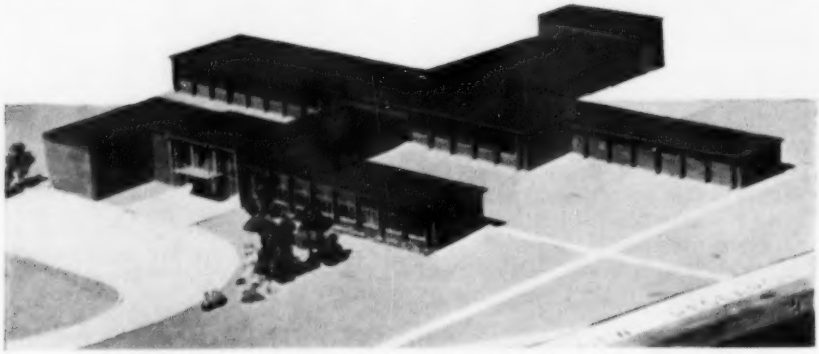


A model of the new research laboratories to be erected at Stewartby

The Largest Brickworks in the World

An Account of a Visit to the Works of London Brick Company at Stewartby, Beds.

By our
INDUSTRIAL CORRESPONDENT

THE Stewartby works of London Brick Co. is located about six miles south of Bedford in a pleasant rural setting. By rail the approach is either from Bedford or Bletchley by means of a local train of two or three coaches hauled by a tank locomotive. Each coach has a retractable set of steps to enable passengers to reach the ground level, for the conventional raised platform is not found in these rural stations. All along the line one sees groups of chimneys locating brickworks, but at Stewartby Halt one notices a grander display than ever and it is quite certain that the journey's end has been reached.

These chimneys soar 225 ft. into the sky, but these are not your angry industrial chimneys at times belching black clouds of smoke over the works, rather are they mellow and contemplative as a man smoking a well-seasoned pipe. They epitomise contentment and an unhurried efficiency—qualities which soon become apparent to the casual visitor. For the operative has every reason to feel contented here with all the advantages of welfare schemes built up by a far-sighted directorate over many years, and it is surprisingly true that the largest brickworks in the world seems to do its job without a lot of fuss. Certainly no time is wasted, and electric and diesel cars move fast, but the whole works has an air of efficiency and calmness which at first sight might be deceptive.

Let us say then first of all that the pre-war production of this plant

was 11,750,000 bricks a week with a total staff of 1,700. At present the number of operatives is about 1,500 in all grades including office staff and the output around ten millions a week.

In common with all the clay industries labour is difficult to obtain in these days and large numbers of European Volunteer Workers are employed, so that all factory notices are displayed in English, German and Polish. There are not many operations at Stewartby that have not been mechanised, but the scarcity of labour has encouraged research to eliminate even these and as will be shown later, striking success in the handling of bricks with a fork-lifting truck has been an enormous contribution to this problem.

Reasons for Situation

What then are the reasons why brick production on such a huge scale came to be located in this part of England? The answer is to be found in the fact that along the valley in which Stewartby is situated and also around Peterborough and parts of Buckinghamshire and Oxfordshire there are remarkable deposits of what is called the Oxford Clay. These were formed in Jurassic times and probably laid down in the estuaries of rivers flowing into the vast Jurassic Sea which covered England east of a line from the coast of Yorkshire to Dorset. These deposits are remarkably uniform in composition, very thick and lend themselves to mechanised methods of clay cutting and the manufacture of clay ware. A further advantage is that the clay contains about 5 per cent of carbonaceous matter so that were it possible to avoid heat losses and to build a kiln operating at 100 per cent. efficiency the bricks could be burnt completely without the addition of extraneous fuel. As it is the fuel consumption is only 1 cwt. per 1,000 bricks. Many a brickmaker using clays requiring

Machinery for clay getting functions admirably with a seam containing very little in the way of rocks and stones

6-7 cwt. of fuel per 1,000 bricks would wish that he were in the same happy position.

Working the Stewartby Seam

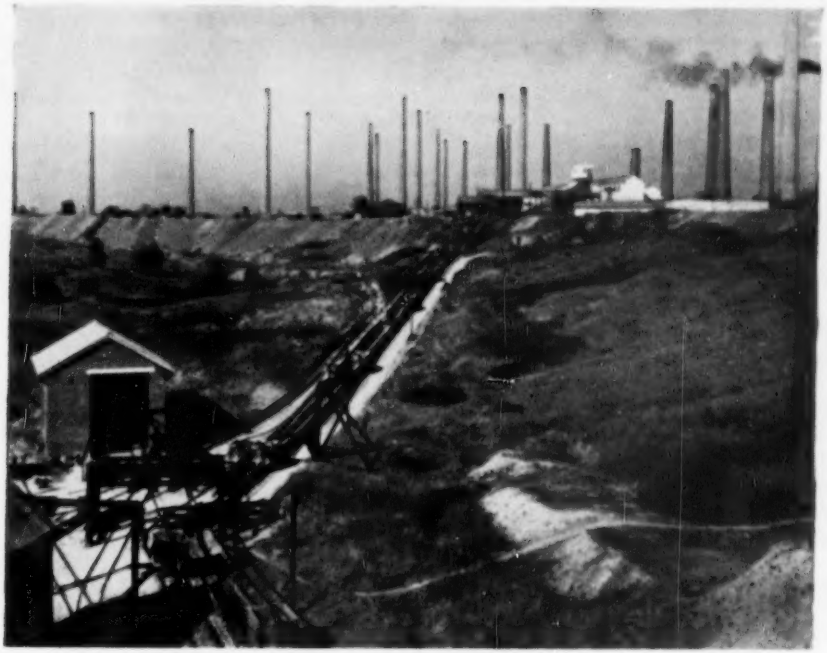
The Stewartby clay seam is about 60 ft. in depth and remarkably level. Some of the other deposits worked by the Company in the Peterborough area are thicker than this. The clay is of the same nature and all told the company's total productive capacity is 35 millions of bricks a week with a production labour force of 5,800.

With a seam of clay of this thickness, containing very little in the way of rocks and stones, large scale machinery for clay getting functions admirably. At Stewartby some 15 ft. of overburden is removed by a drag-line, loaded on to a long jib conveyor and dropped back into the worked out portions of the pit. Incidentally the company do not visualise leaving an unsightly worked out clay pit when clay-getting is completed. Instead, an artificial lake will be formed with trees planted around.

The 42,000 tons of clay required at Stewartby each week requires the excavation of about half an acre of ground. A single electric power shovel digs all the clay required, scooping up the whole of the clay face with a 10 c. yd. bucket.

This clay is then dropped into a hopper and fed on to a belt in a sorting machine. Here lumps of rock and fossils are removed and large lumps of clay reduced in size with kibbler rollers. The clay is then dumped into trucks hauled by a diesel locomotive to an endless chain haulage system. Here the loaded wagons, each weighing 6 ton, are hooked on to the chain which

Loading clay on to the sorting plant, where rocks and fossils are removed, and large lumps of clay reduced in size with kibbler rollers



A view of the works, showing the chain haulage system

has a total length of about 2,800 yd. Sufficient clay (about 2 ft.) is left in the bottom of the pit to carry the excavator machinery and the rail track, since under that is sand. The machinery is moved as excavation proceeds.

Works Operation

As the trucks arrive at the works they are run on to electrically operated "tipplers" built to the company's own design. Two of these distribute the clay from the pit, into storage bins—the trucks being inverted bodily before being returned to the chain system.

The clay comes from the pit with about 19 per cent. moisture, and this remains very constant, so that it can be used by simply grinding and pressing it. It is, therefore, fed from the bins into two rows of pan grinders by oscillating metal plates. Here the clay is ground and dropped into boots from which bucket elevators carry it to rotary screens.

Under ground material is returned to the grinding pans, and the correctly ground is passed on to rubber composition conveyor belts feeding the brick presses below. The presses mould the clay into bricks between steam-heated dies using four progressively increasing pressures. (Hence the trade name Phorpres.)

Kiln Setting

The pressed bricks are delivered at a high rate, and both ordinary and rustic types are made. Agricultural drain pipes are also produced by an unusual press designed by the company. The pressed bricks are loaded on to electric cars and carried to the kilns for setting. They need no preliminary drying, and are strong enough to stand handling in this state. This saves

time, space, fuel and labour for handling operations.

At present a great deal of the setting and unloading of kilns is done by hand. Two men can set a chamber kiln of 30,000 - 40,000 bricks in a day. Attempts to mechanise this operation and the one of unloading has engaged the attention of the company's works department for some years.

Car tunnel kilns were built in 1929 as one experiment in this direction, but they were abandoned in favour of continuous chamber kilns into which the bricks are set on the tunnel kiln type of car, set at the brick press. This affected great savings in handling, but the cars and transfer machinery were necessarily heavy, and maintenance a problem. These kilns have now been converted to lift-truck operation.

Electric transfer cars setting bricks in the kiln

Development of Lifting Fork

For some time now reports have been published in the British and American journals of the use of brick lifting forks in conjunction with cranes and fork-lift trucks for handling green and fired bricks without the use of pallets (cf. *British Clayworker* **57**.139.149; **59**.16.1950). Using a Priester brick fork and a crane, one man is described as moving 100,000 bricks a day on one American works.

It is gratifying therefore, to note that the London Brick Co., have developed their own type of lifting fork (British Patent No. 633,180) which, when used in combination with a fork lifting truck (now built in this country to the firms own specification) allows the setting of a chamber holding 72,000 bricks in 3 hours, with rather less time for drawing.

Briefly the use of a brick fork involves stacking the bricks into piles of roughly a thousand bricks leaving spaces in the bottom layer for the insertion of the fork. The tines of the fork are made to expand

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after insertion, and grip the bottom layer of bricks firmly together forming a base on which the remainder of the load can be lifted. In some American versions the expansion of the tines is done mechanically—in the type developed at Stewartby gripping is done by inflating rubber sacks located in cavities on the sides of the fork tines. To facilitate the use of fork lifting trucks the bricks are stacked on a template, so that space is left for the insertion of the forks. Thereafter the bricks are moved in units of about 1,000. It is obvious that this system is capable of extended use and will probably solve the problem of the tedious and expensive operation of hand setting and drawing.

Sand Facing

Sand facing of bricks is in process of complete mechanisation. The pressed bricks are delivered on conveyors to the sanding machine. This comprises a blade for fettling the brick, swarf is then blown off, and the brick passed under a short steam-heated tunnel, which brings sufficient moisture to the surface to allow the sand or grog to penetrate the surface in the subsequent operation in which sand is blown on the brick by compressed air.

After sanding the bricks are stacked and loaded by fork lift truck into the kiln. Some very beautiful coloured bricks are produced by this process.

The firing is really impressive. One kiln has 80 chambers each holding about 70,000 bricks and there are five fires chasing each other round. It is 280 yards long and the firing cycle is about 14 days.

The company owns its own fleet of some 500 lorries and does its own maintenance and repairs. Delivery is either made by road or from the nearest railway, where longer distances are involved. It should be mentioned that it owns a foundry and engineering shops at Peterborough, in which much of the specialised machinery is built.

New Laboratory Building

To enable the Research Department, to enlarge its activities a new laboratory building is being erected at Stewartby. Those who feel that with such an old established industry as brick making there is very little more to be learnt, would find a short conversation with the research team at Stewartby, an interesting and stimulating experience. They have no difficulty in stating a case for extensive research into brick making, or of justifying the expenditure required for this.

Model Village

No account of Stewartby would be complete without some mention of the model village and the welfare schemes inaugurated by the company. The model village was commenced in 1927 with the erection of fifty houses—twenty-four parlour and twenty-six non-parlour type. Subsequently a further sixteen houses were added. The style of architecture is dignified and naturally the company have seen to it that the brickwork is mellow in colour, forming a harmonious whole with the landscape. A very striking village hall forms a centre for the numerous social activities. It is a reproduction of an old market hall and makes an immediate appeal to the visitor to the works.

A scheme for a further 136 houses was commenced in 1935—these being built in blocks of two, four or six houses, the accommodation varying from two bedrooms and bath, living room and kitchen to three bedrooms and parlour. All are provided with mains water and drainage and the rents vary from 7s. 6d to 12s. 6d. per week including rates.

The population of the village with the houses so far completed is about 1,000. In addition the company has provided a sports ground and children's playgrounds and a very fine open air swimming pool.

The welfare services include the provision for full-time personnel officer and staff. Canteens and

messrooms and fully staffed clinics are available. The employees manage their own social and sports association.

A profit-sharing bonus scheme was introduced in 1926 and 10 years later a pension and life assurance scheme. The whole cost of the life assurance is borne by the company, who also pay the greater share of the contributions to the pensions scheme. One week paid holiday a year is given to all employees who have completed one year of unbroken service.

This then is a record of a company making 35 million bricks a week. It sounds an enormous quantity—but still there is a scarcity of bricks!

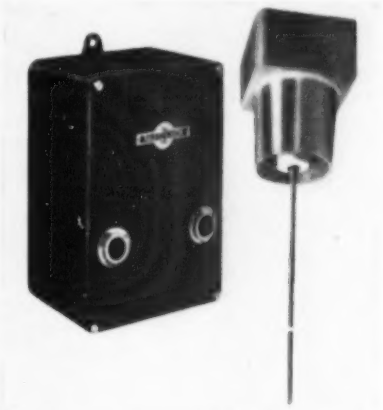
BUNKER LEVEL CONTROL

An Automatic Device

A VARIETY of interesting uses have been reported for the B.L.49 bunker level control introduced recently by Radiovisor Parent Ltd., of 1 Stanhope Street, London, N.W.1. This simple unit, which is quickly and easily screwed into position, incorporates a projecting rod type electrode which may be of any length to suit the requirements of the installation. It is electrically connected to a neat control unit comprising a single-stage thermionic valve amplifier incorporating red and green lights and terminals for connection to an external audible alarm.

An interesting application of this equipment is to control the level in bunkers holding coarse, crushed silica stones, the moisture content of which varies up to 15 per cent. In the past, due to inattention on the part of the operators, damage and hold-ups have been caused through failure to stop the feeding mechanism when the bunker was full, and thus the introduction of some form of foolproof and automatic control became imperative. When damp, this material sticks to glass with a tenacity almost equal to that of cement. Consequently, the use of ordinary photo-electric methods involving the projection of a beam of light on to a receiver, is not possible because of obscuration of the glass windows. The material is stored in a twin-bunker fed from a common chute having a two-way outlet which, by movement of a plate valve, can be arranged to discharge into either bunker. Two 12 in. electrodes, one in the top of each bunker, are connected to a common control panel; to avoid chances of damage, the position was chosen so that neither electrode is in the direct line of flow of the material as it discharges into the bunker.

Except when the bunker is full, a green light shows on the control panel, indicating that filling can proceed. However, when the material level rises until it touches the electrode, a circuit is completed, thus closing a relay and causing a red light to show. At the same time, the motor responsible for feeding the material to the chute is automatically stopped, and an audible alarm sounded to attract the attention of the operator.



Bunker level control unit, incorporating a projection rod type electrode

Obviously, the control system can be extended so that, as the material is drawn off and the level falls, it uncovers a second electrode. When this occurs, the motor would be restarted to refill the bunker. A somewhat similar unit is also being installed for controlling the level in bunkers used for the storage of fertilisers. It will be appreciated that the above equipment is equally applicable for controlling the levels of liquids in bulk storage tanks, etc.

Building Materials in Antiquity

by

NORMAN DAVEY
D.Sc., Ph.D., F.S.A., M.I.C.E.

IN this paper read before the Road and Building Materials Group of the Society of Chemical Industry some time ago, the author gave an interesting account of the transition in building materials from simple stone or mud huts to modern usage, and drew attention to the continuous changes in technical development, but pointed out that the basic materials, namely stone, brick, binding materials, roofing materials and the like have remained more or less the same throughout.

Stone Working

Among the earliest attempts at wall building were large shapeless pieces of intractable rock which were infilled by smaller stones as well as earth and clay. The walls were thick and low. Then the possibility of trimming to give closer joints which did not need filling was developed, but this was held up until the development of metal tools, chisels, etc. In Egypt this stone working was occurring about 3,000 B.C.

The next development was the selection of building stone which fractured with a horizontal cleavage. Then came mortar which attained strength on hardening, and this method of construction was known to the Romans.

The transition from stone to concrete walls came when instead of using small stones as a facing to the concrete core, the stones were laid in layers and each layer had a grout of mortar poured over it.

Early attempts to build walls in mud and clay were disappointing due to drying shrinkage and cracking. It was soon realised that it was better to use small lumps of clay roughly moulded into shape and allow them to dry in the sun before use. Chopped straw strengthened the blocks and assisted evaporation of moisture from the interior. In Babylon and Egypt, clay was moulded into rectangular blocks or bricks and laid in mud mortar in horizontal courses.

Burned bricks were used in the ancient cities of Babylon 6,000 years ago and the Babylonian and Assyrian attained a high degree of efficiency in brick making, notably in the manufacture of bricks which had a coating of coloured glaze or enamel. The burning of bricks was carried out in clamps and later in up-draft kilns.

Binding Materials

Among the binding materials mud or clay was the earliest one used that was with additions of such things as chopped straw or grass for bedding stones and bricks and rendering walls.

Gypsum plaster was used in Egypt and Assyria over 6,000 years ago. Burnt raw gypsum to form plaster needed a lower temperature than to burn limestone to produce lime. The latter process was known at an early period in Greece and later in Crete and the ancients used mostly the non-hydraulic types. They added however, partially hydraulic types of material.

The well-known pozzolanic, after Pozzuoli in Italy, was made from pounded tiles, bricks and pottery, burnt clay, slags, pumice, earths and clay of volcanic origin. This needed a temperature of about 850° C. The Romans used pozzolanic mortars to prevent moisture penetration, for

Chemistry and Industry, 1950, pp. 43-47.

lining the insides of channels, drains baths, tanks, and so on. In Britain no natural pozzolanic was available to the Romans and they used artificial ones such as crushed brick.

The use of bituminous mortar for building work dates back to 3,500 B.C. in Babylonia.

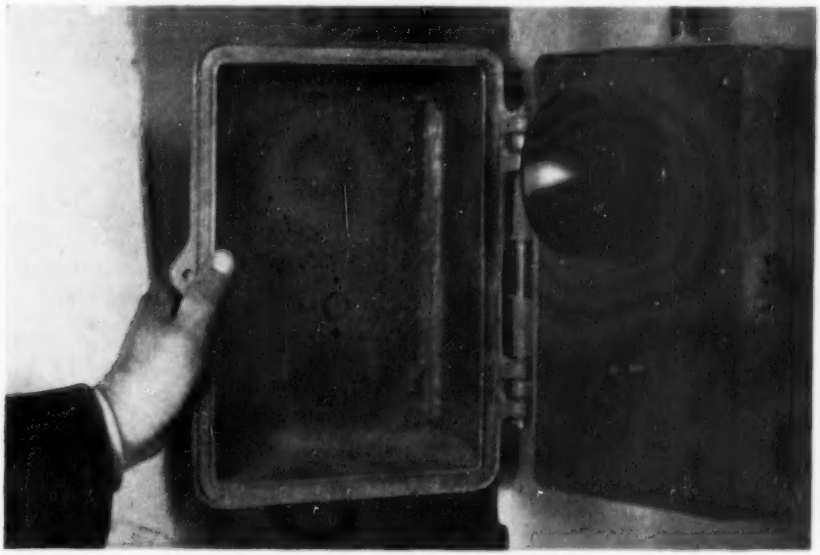
What is important to note is that the traditional techniques of building in stone and brick have changed little through the ages.

Inter-Communication Equipment

A Cement Works Installation

THE loading of cement, as of other industrial products, presents problems which can be simplified and speeded-up by modifications or additions to existing equipment. After studying the question of loading-control, the Rugby Portland Cement Co. Ltd., came to the conclusion that valuable time could be saved by the installation of an audible network of communication, and requested the British Thomson-Houston Company to study their needs. As a result, an inter - communication system has recently been installed at their Southam works, where there are two packing stations each feeding five loading points—two for road, two for rail, and one for canal transport, the latter being some 400 yds. from the packing station. This inter-communication system enables the operators at either packing station to speak to the loading teams which they serve and vice versa.

With this arrangement, as opposed to other communication systems using signal lights, bells and telephones,



Each unit is housed in a heavy-gauge sheet-steel case, fitted with a spring-loaded, dustproof door

each worker in the team knows immediately of any change in the normal routine, such as shortages, which might arise from burst bags at the loading station, necessitating replacements from the packers. There are seven points in the loading and packing sections of the Southam works where supervisory control is necessary to facilitate the rapid handling of various grades and quantities of cement. At each of these points, a speaker-unit and control-box incorporating a microphone has been installed.

Increased Efficiency

The system has eliminated many of the delays inevitable when orders and instructions have to be relayed by other means, and although comparative figures are not yet available (the system has only been in operation since 26th June, 1950), it has definitely been established that the efficiency of the plant has increased considerably.

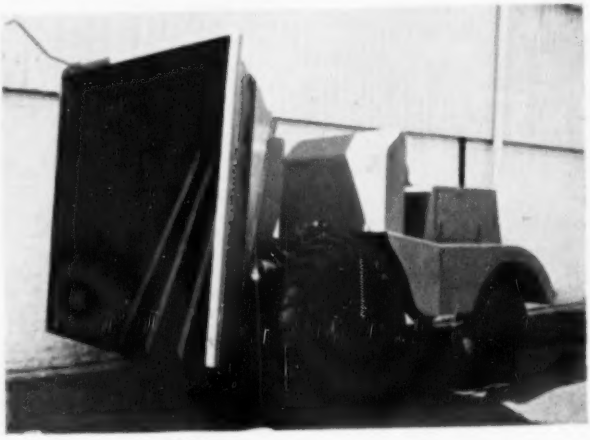
The equipment has been designed to operate under the arduous conditions encountered in cement works and special attention has therefore been paid to methods of excluding cement particles. Each unit is housed in a heavy-gauge sheet-steel case fitted with a spring-loaded dust-proof door to ensure that the microphone and controls are protected from all foreign matter. All switches used in the equipment are totally enclosed, thus eliminating the possibility of high resistance at the contacts, which might arise from the ingress of cement particles. The horn speakers are of the re-entrant type and lend themselves admirably to use in such locations as it is practically impossible for foreign matter to enter the actual speaker unit. The complete equipment is built to a "tropical" specification.

Many Applications

Although the installation, as described was specially devised for this particular application, the equipment is standardised for use in all industrial locations. Meticulous care has been taken to ensure the production of robust and thoroughly reliable units which, moreover, permit flexibility in system layout, as well as extensions and easy rearrangement to meet the needs of changing local conditions.

There are many applications in continuous processes and conveyor systems, ranging from engineering industries such as steel and tube mills, and motor-car assembly lines, to flour mills and food packaging systems, where this system can prove its worth.

A stoppage or breakdown at any point in a continuous process, even for a relatively short time, can be costly, both from the point of view of money and wasted materials. In such an event each keypoint can be informed immediately of all details and at the same time, maintenance personnel, usually spread about a large works, can be summoned immediately.



The Chaseside Engineering Co. Ltd., of Station Works, Hertford, announce that their 3 c. yd. dumper can now be supplied with a Perkins P.6 Diesel engine as an alternative to the Ford V.8 petrol engine. A further advance is represented by optional reinforcement of the dumper skip, making it more suitable for quarry work, or for similar heavy duty

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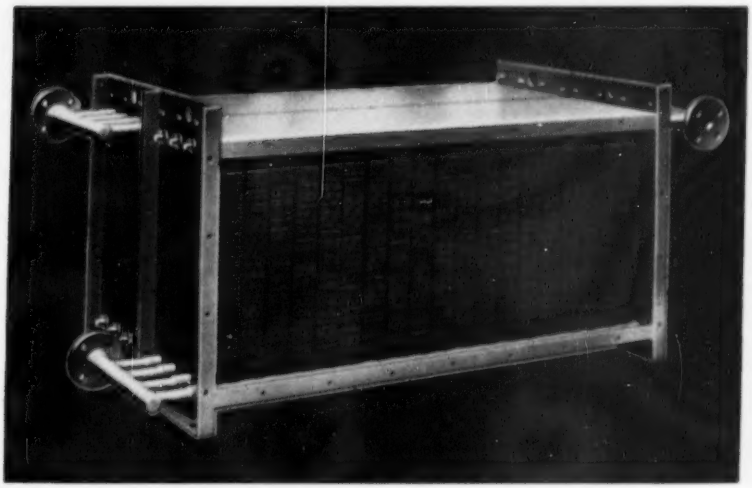
AIR HEATERS FOR PROCESS WORK

It has long been agreed that to dry efficiently, it is essential to have fresh supplies of air as well as heat. The Weldex Heater Batteries for this type of Heating are similar to those supplied for plenum systems but have unlimited application for process work equipment. Temperatures within 20 degrees F. of the heating medium can be obtained and any quantity of air dealt with. Typical applications already in operation are:

1. Milk Bottle drying.
2. China Clay drying.
3. Leather drying.
4. Cotton and Wool drying.
5. Paper drying.
6. Flax and Linen drying, etc.

In addition, such things as Sand Cores or Moulds can be dried in this way with steam pressure under the 100 lb. per sq. in. mark. The Weldex Air Heater is very robust, and of all steel construction. Weldex also specialise in the design of efficient Cooling Systems, the necessary information required being:

1. Volume or Weight of air to be cooled.
2. Inlet air temperature.
3. Required outlet temperature.
4. Humidity Conditions.
5. Cooling medium and its flow and return temperature.



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Industrial Hazards

Reports of Some Accidents

THERE is an increasing danger to life corresponding to the increased tempo of modern production. Unfortunately so many accidents occur after which it is easy to be "wise after the event." Thus the publication "Industrial Accidents," published quarterly for the Factory Department, Ministry of Labour, by H.M.S.O. at 3s. 6d. per annum, is doing an excellent job by a factual report of accidents which occur. No attempt is made to imply blame, but causes of specific accidents are outlined and they thus serve as a grim reminder to others.

Here are one or two which have taken place with plant and processes used in the ceramic industry.

Bursting of Water Gauge on Boiler

A glass splinter penetrated a man's eye when the water gauge tube of a boiler burst whilst being cleaned. The gauge was provided with a guard as required by Section 29 1 (a) (iv) of the Factories Act 1937 but it had been removed during the cleaning. A recognised drill had been adopted for this necessary work and operated in the following sequence. Before removal of the guard, the steam and water cocks connecting the gauge to the boiler were closed and the drain cock opened after which the guard was removed.

On this occasion the drain cock had not been opened, consequently steam and water remained under pressure in the gauge and it is thought that the operator, not having given time for the water and steam to cool down, removed the guard clumsily and struck the tube, which burst with sufficient violence to scatter the glass over the boiler house.

The man although well versed in boiler house practice, must have been careless or forgetful of the recognised procedure or taken a risk because the drain cock was a little tight. This type of accident demonstrates the necessity for following strictly any drill laid down, and the need for maintenance to ensure that vital fittings remain free in operation, so reducing the possibility of risks being taken. It is also important that only trained men thoroughly conversant with boiler house practice should be employed, otherwise similar accidents might occur because of ignorance of the correct procedure to adopt.

Cement Mixer Fatality

The cause of two successive failures of a works electrical power supply system during a single afternoon was wrongly attributed by the workmen to load shedding, when in fact the failure on each occasion was due to a fault in the system. When the second failure occurred, the men thought there would be no more work during the shift and decided to clean the machines. One of them got into the pan of a cement mixer and nobody noticed that the starter had remained in the closed position. It was assumed that it would trip automatically when the supply failed. Shortly afterwards the supply was restored and the cement mixer started up; the workman was trapped and severely injured. He died shortly afterwards.

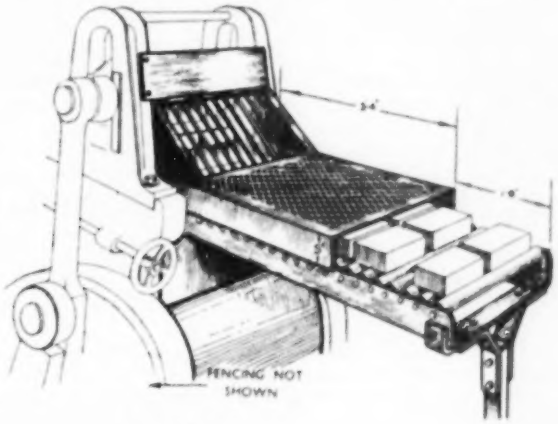
Subsequent examination revealed defects in the starter which was of the fixed handle, hand operated star-delta type with automatic no-volt and overcurrent release. Although the correct operating procedure was to use the handle to start the motor and a push button to stop it, the handle had frequently been used instead of the push button to switch off. This had caused straining of the latches and triggers, made from light gauge metal pressings, which operated the automatic releases and the adjustment for automatic working had become inaccurate. This was undoubtably the main reason for failure of the starter, but the presence of cement dust in the starter case causing friction and possible bad

Illustration showing how accident, due to an ineffective guard on a brick press, was caused

contacts, might have aggravated the position.

Ineffective Guard on Brick Press

After the supply of material to a semi-dry brick press had been cut off, a workman began to remove formed bricks from inside the tunnel guard before the machine had come to rest. At the outer end of the tunnel was a close fitting flap opening outwards and so designed as to make it difficult for it to be raised from outside. In this instance it had already been raised by the bricks inside the tunnel. When the man was reaching down the



An example of an effective long tunnel guard

tunnel to remove the last of the bricks, the tips of three fingers on his left hand were cut off, between the top plate and die.

The delivery opening at the end of the tunnel was 18½ in. from the trapping point and was obviously not of sufficient length to prevent a hand reaching into danger. The flap, as the accident shows, was ineffective in preventing initial access to the tunnel but in any case such flaps are liable to damage and can too easily be raised from the outside.

Flaps are superfluous as the tunnel is long enough to prevent the top plate and die from being reached and the second illustration shows such an effective long tunnel guard.

The passage of bricks through the tunnel is facilitated by either a gravity roller conveyor (as shown), an incline delivery table or a hand conveyor.

Overturning Crane

A 3 ton mobile crane overturned on a building site due to a load being lifted which was in excess of the safe working load. The automatic indicator started ringing as soon as the load was picked up but the driver, disregarding that warning, as he had disregarded the warning of the red light in his cab, continued to lift and slew at the same time. He was fortunate to escape with comparatively minor injuries when the crane overturned. The banksman who had slung the load and who knew it was beyond the safe capacity of the crane was dismissed, but a very large measure of blame for the occurrence attaches to the driver who should have refused to lift the load as soon as the indicator gave warning.

An automatic safe load indicator informs the driver of the state of loading of his crane by a green light showing when the load lifted is within the capacity of the crane but when the crane is overloaded a red light automatically appears; a further warning of serious overloading primarily intended for people working in the vicinity is given by the ringing of a bell. Overload warnings must be regarded as indicating that a dangerous situation has arisen and to ignore them is to risk the most serious consequences.

Run Over by Tractor

The engine of a tractor being used in a factory yard was left in gear after it had stalled, and when the driver restarted it by the hand crank the tractor moved forward. The driver managed to jump clear and as the tractor passed him he leapt into the saddle, but was only able to sit sideways. He steered past two obstructions but was unable to avoid a third completely. The resulting impact threw him from his seat and under one of the rear driving wheels, causing severe internal injuries.

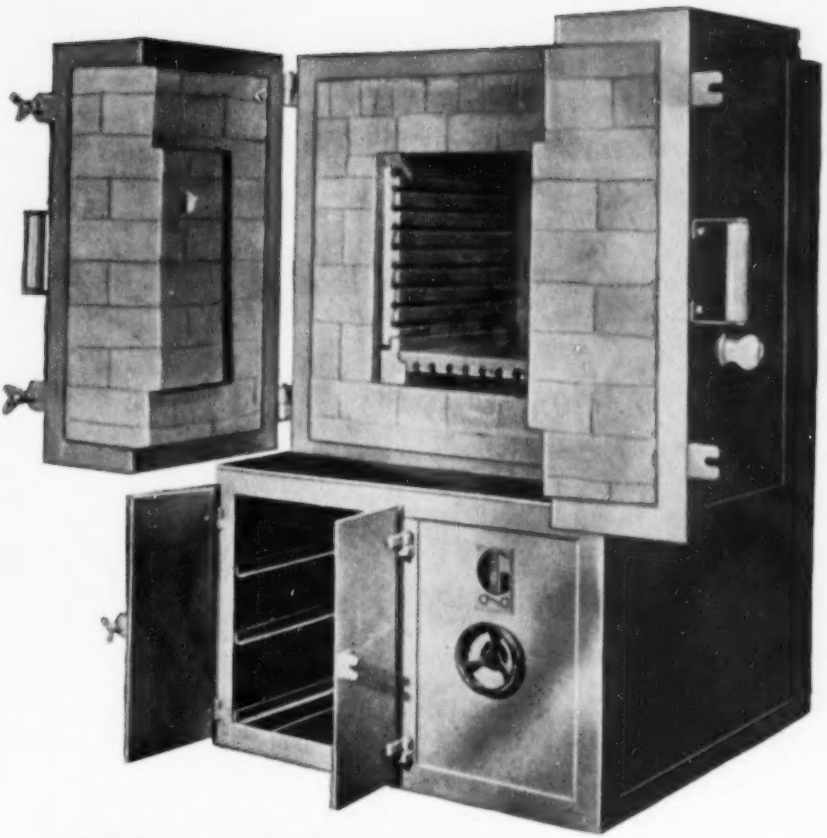
When the driver leapt into the saddle he accidentally opened the throttle hand control which was immediately under the steering wheel, and so increased the tractor's speed. His sideways position also prevented his reaching either the brake or the clutch pedal.

Starting the engine in gear was the prime cause of this accident which might have been prevented had the hand brake been effectively applied to stop any movement of the tractor; additionally, the driver might have been able to prevent himself being thrown under the rear wheel had this been provided with a mud-guard to which he could have clung.

EXPANDING PRODUCTION IN SCOTLAND

AN expansion of ceramic finishing work has been a feature of the stoneware industry in Scotland in recent months, with the Govancroft Potteries Ltd. in Glasgow as the main centre for this activity. The traditional stoneware glaze finishes have been supplemented by a wide range of alternatives, including some magnificent lustre ware types, unique in Scotland. The work has been facilitated by the installation, over the past 2 years, of a modern gas-fired tunnel oven replacing the older bottle kilns used in this part of the plant.

The new oven has given excellent results and is facilitating not only expanded production but the production of types formerly unobtainable in the area.



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M-W 109

Modern Trends in Design

Continuous Firing Kiln for Pottery and Glazed Tiles

by

B. M. MURRAY

(British Ceramic Services Ltd.)

In common with the general progress being made in ceramic production, designs of continuous firing tunnel kilns have likewise made considerable advancement.

These advances have been, and are being made in the following directions: 1. A closer optimum relationship between tunnel kiln setting, cross sectional area and kiln length. 2. Improved control of heat release to ware in the preheating and firing zone. 3. Greater evenness of applied heat to ware throughout the setting at all stages of temperature increment and decrement. 4. Employment of better refractories and insulating materials throughout the kiln structure and kiln cars. 5. Development of durable car superstructure. 6. Greater use of heat recuperation. 7. Greater use of labour saving and labour guarding devices in kiln operation. 8. Improved burner systems with requisite furnace construction. Fuel consumption. 9. Use and application of various fuels. 10. Maximum efficiency in capital and operating expenditure. 11. Reductions in firing losses.

IN the earlier years of tunnel kiln history the choice of kiln cross section was dictated greatly by economics—i.e., lowest capital outlay for a given output. This resulted in an improvement over bottle kiln firing but still left an undesirable volume of firing losses due to imperfect control of heat input throughout the car setting, throughout the kiln firing cycle.

It has been found that these older kilns had some really bad faults. The temperature increment generally was insufficiently controllable at various stages of the early treatment of the ware. Furthermore, due to the specific heat properties of the materials being fired the greater the cross section the less effective was the heat treatment of the ware towards the lower centre of the setting. On entering the firing or soaking zones the ware in the central lower part of the setting was subjected to severe increment temperature shock which it failed to withstand.

It was therefore necessary to reduce the cross section widths of tunnel kilns to an optimum value determined by the study, and use of trial samples, and Buller's Rings or Cones, throughout the settings. This began the reduction in cross section widths and today the present general optimum widths for tunnel kilns are as given below:—

	in.
Open placed china biscuit kilns ...	27
Open placed earthenware biscuit kilns	38
Open placed tile biscuit kilns ...	38
Radiant tube muffle china glost kilns	18
Radiant tube muffle earthenware glost kilns or with arch tunnel 34 in. wide	18
Open placed tile glost kilns	18
Radiant tube muffle enamel kilns ...	18

All of these have been and can be designed to give extraordinary close temperature control across the setting.

A lecture to the British Pottery Managers' and Officials' Association, Stoke-on-Trent, 4th September, 1950.

Setting Height and Lengths

Correspondingly, from similar tests and the general use of travelling car pyrometer records for these optimum setting widths, one arrives at desirable and controllable setting heights as follows:—

	in.
Open placed china biscuit kilns	36
Open placed earthenware biscuit kilns	42
Open placed tile biscuit kilns	30
Radiant tube muffle china glost kilns	24
Radiant tube earthenware glost kilns Arch tunnel 36 in.	24
Open placed tile glost kilns	27
Radiant tube muffle enamel kilns	24

Having arrived at the optimum kiln cross section various considerations affect the optimum range of the kiln lengths which will meet the desirable pre - heating — firing or soaking and cooling zone lengths. Temperature increment rates—soaking periods and safe cooling speeds in relation to the type of body and ware as well as final maximum temperature are all now better understood.

The optimum range of kiln lengths for the above cross sections are approximately as follows:—

	ft.
Open placed china biscuit kilns	130-200
Open placed earthenware biscuit kilns	150-270
Open placed tile biscuit kilns	150-270
Radiant tube muffle china glost kilns	90-175
Radiant tube earthenware flat roof type	90-175
Radiant tube earthenware arch roof type	120-160
Open placed tile glost kilns	100-160
Radiant tube muffle enamel kilns	65-130

Firing Cycles and Outputs

Employing the ware bodies, glazes and decorations at present in use one can generally assume the following total firing cycle optimum times for efficient production.

	hr.
Open placed china biscuit kilns	48
Open placed earthenware biscuit kilns	60
Open placed tile biscuit kilns	60
Radiant tube muffle china glost kilns	20
Radiant tube earthenware flat roof type	24
Radiant tube earthenware arch roof type	24
Open placed tile glost kilns	24
Radiant tube muffle enamel kilns	15

Based on the foregoing we obtain the following approximate throughputs per week of 168 hours:—

	c. ft.
Open placed china biscuit kilns	3,000/4,750
Open placed earthenware biscuit kilns	4,500/8,350
Open placed tile biscuit kilns	3,250/6,000
Radiant tube muffle china glost kilns	2,250/4,500
Radiant tube muffle earthenware glost kilns (flat roof type)	1,850/3,700
Radiant tube muffle earthenware glost kilns (arch roof type)	7,500/9,500
Open placed tile glost kilns	2,300/5,400
Radiant tube muffle enamel kilns	2,000/4,000

All of these performances are optimum but all kilns of modern design and incorporating all present improvements are capable of efficient operation over a wide range of throughputs.

Pre-Heating and Firing Zone Heating—Biscuit Kilns

In the kilns of older designs the general principles of pre-heating lateral and longitudinal heat distribution throughout the setting were relatively ineffective. This resulted in a wide variety of losses and poorer quality ware.

During the past 5 years much research work has been done and modern kilns greatly overcome the earlier difficulties. The general trend has been towards a far greater number of burners more scientifically located in relation to the optimum firing curve required by the ware and a greater number of exhaust ports, the re-heated gases from which can be directed either back into the tunnel proper for recirculation or diverted to earlier sections of the pre-heat zone.

Taking earthenware biscuit as an

example, the removal of the mechanically combined moisture must be removed at a still more gentle rate while the expulsion of the chemically combined moisture must be removed at a still more modest rate if uncracked and straight ware is to result.

Further developments in hand are the re-circulation of high temperature gases at low velocities but large volumes after the chemically combined moisture has been removed.

Various experiments have been made and are being carried out on the under-deck space dimensions in relation to tunnel clearance annulus, as it is felt that the criminal tendency for top heat drift can be better controlled by correct relative bottom —side—and top clearance areas.

Even Heat Application to Ware

In the case of firing zone designs the tendency has been towards more steady and unvarying temperature increment and maintenance during the entry into and soaking period duration.

Here again a large number of correctly placed burners located in furnace chambers of specially designed widths and heights in relation to the foregoing optimum setting heights manifestly improve the heat release to ware by guiding the products of combustion to where they can be most efficient.

By the adequate and correct application of draft and CO_2 gauges it is now possible to balance the tunnel atmosphere to any degree of turbulent gas volume and also maintain a correct oxidising atmosphere where it is desirable to attain bright ware.

As an example, kilns have been operated for long periods with a maximum variation throughout the setting of 3 Buller Rings while the average is generally even less than this. In cooling the advancement is towards more controllable tunnel direct cooling with adequate final cooling before the cars leave the kiln and greater multiplicity of indirect cooling wall control ports.

Structure, Refractories and Insulation

In the design of kiln furnace walls, firing zone arches, etc., much more attention is given to perfectly close jointing, since poor jointing is conducive to high maintenance and greater heat losses.

Refractory manufacturers are producing still higher grade refractories and in tunnel kiln construction it is imperative for durability to use only refractories at about 100° C. below their load test values. Previously the employment of diatomaceous powder was common practice, whereas today greater heat economies are attained by the more judicious use of correctly made insulating bricks to back up the refractory walls. Indeed, recent measurements show that the maximum surface temperature of any part of a kiln firing to 1,120° C. was only 70° C., and was within 5° C. of the calculated value determined by the insulation heat percolation.

One of the most important items in tunnel construction is the expansion joints and their location. Modern kilns seldom show even minor cracks due to the correct location and design of these.

Kiln Cars

The insulation of kiln cars and the construction of durable refractory tops is of major importance from a fuel economy and maintenance cost point of view. Refractory tops should have adequate expansion with platform rigidity and where gaps occur these should be wider underneath to provide for cleaning out. The graded car insulation usually consists of mats of insulating bricks rated at 1,350° C.-1,100° C. and 900° C. with a foundation bed of insulating refractory grog. The resultant measured under car air temperature when using sand

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BLAST FURNACES Foundations, Throats, Flue Linings, Pig Iron Runners

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CUPOLAS Top Linings above melting zone

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ELECTRIC MUFFLE FURNACES Precast Blocks, Doors, Linings, Wire Element Retainers

FLOORS Heat-resisting Foundry

GAS-WORKS Retort Ends, Flues, Top Paving, Quenching Floors, Carburettor Head Tiles, Foundations

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seals and under car cooling air is about 50° C.

Heat Recuperation

Most burner systems now employ pre-heated air from the cooling end panels while the quantity of waste heat available from tunnel cooling is very low indeed in a correctly balanced kiln.

Further developments are in progress to recuperate heat from exhaust systems by heat exchangers using special metals now available. It may be feasible thereby to obtain further heat regain.

Labour Saving and Guard Devices

There is an increasing use of haulage and hydraulic pusher equipment on the return tracks while kiln loading and off loading is greatly facilitated by the use of continuous suspended conveyors of the multi-tray type.

All modern kilns should be fitted with pendulum stops at each rail end to prevent cars being pushed off their tracks. Gas supplies should be protected by electro-magneto valves in event of electricity failure or stoppage of exhaust fans. Limit switch trips should be fitted to stop pushing gear and ring alarms to cover possible incorrect car operation.

Fuel Consumption

Considerable gains in fuel consumption have been achieved and as examples it can be mentioned that an earthenware tunnel biscuit kiln producing 12,000/15,000 dozens of twelve of ware per week consumes 23/26 tons of coke when fired by clean producer gas.

A radiant tube muffle glost earthenware kiln firing 10,000 dozens of twelve per week consumes 2,200 c. ft. of towns gas per hour.

Kilns have had to be developed to fire oil, producer gas, towns gas or a combination of all three and successful performances have been attained.

Capital and Operating Expenditure

Since tunnel kilns form a long term investment their initial cost within reason is not of prime importance. Their annual throughput value is vastly greater than their cost when higher grade refractories durable designs are employed the savings are considerable and operating costs low.

All the foregoing developments have led to a reduction in the all important figure of firing losses.

Future Trends

The future developments being pursued are:— (a) Faster firing bodies. (b) Open fired car superstructures of greater strength, durability and less weight with better heat conductivity. (c) Equipment to re-circulate gases at elevated temperatures. (d) Higher grade refractories permitting heavier insulation and further heat economies.

In conclusion I would commend all those interested to follow the excellent work being done by the British Ceramic Research Association, and pay tribute to the most helpful collaboration always enjoyed from all members of the Pottery and Ceramic Industries and my colleagues in the British Ceramic Service Co. Limited.

RUBBERISED FLOOR PAINT

FACTRON Products are now marketing a rubberised floor paint in nine attractive colours. A two coat application is recommended for concrete, lino and wooden floors both interior and exterior. The paint is chemically resistant and is claimed to give protection against mild acid and alkali attack. It can also be applied direct to new concrete omitting the normal neutralising treatment. Designed for use in factories, offices, hospitals, schools and other industrial buildings, it is washable, easily polished and provides a tough coating to withstand heavy foot traffic.

Particulars and leaflet from Factron Products Ltd., 14 North End Road, London, N.W.11. Tel.: SPEedwell 8480.

Magnetic Filters and the Pottery Industry

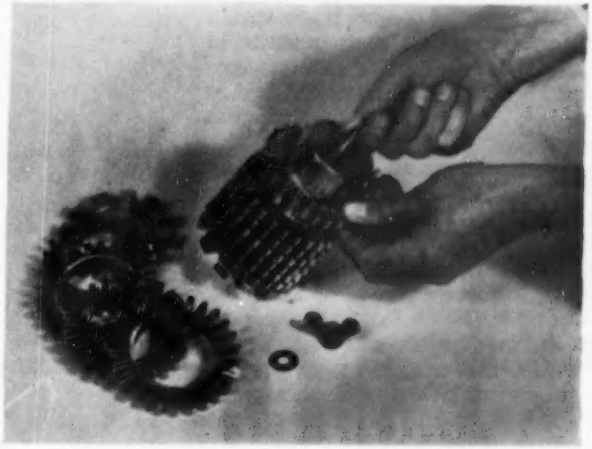
by

R. A. ETHERINGTON
(Industrial Department, Philips Electrical Ltd.)

THE ferrous contamination encountered in the materials used in the Pottery Industry is natural iron in the constituents, or wear from machinery used in pumping, piping and grinding these materials.

One has only to examine the difference in quality between ceramic ware efficiently "magnetted" to appreciate that the expenditure on filtration machinery will be well repaid as, of course, the highest quality can always command the highest price.

It needs no explanation that white tiles, white pottery or china are marred by the black and brown stains of unfiltered iron particles, but it is not generally known that in coloured ware, where contamination can be covered or unnoticed, the presence of undue quantities of iron will cause distortion. This is particularly noticeable in tile manufacture and causes a lot of wastage, where no magnetting system is used. Manufacturers using standard magnetic appliances are often puzzled by batches of ware suddenly showing up bad contamination and often do not realise that, even with porcelain rams, every pumping



Dismantling the new Philips magnetic assembly for easy cleaning

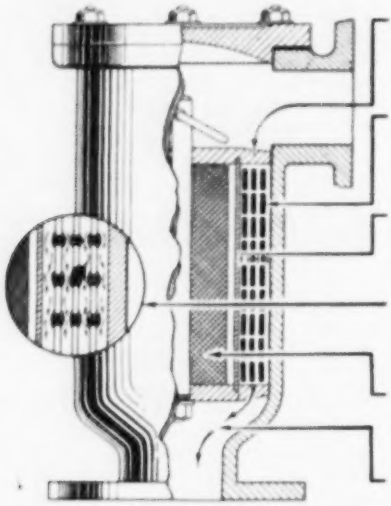

INLET
MAGNETISED IRON FILTER CAGE
FREE FLOW OF LIQUID THROUGH FILTER CAGE
FERROUS CONTAMINATION COLLECTS ONLY IN GAPS BETWEEN FILTER SEGMENTS
POWERFUL "TICONAL" PERMANENT MAGNET
OUTLET

Diagram showing details of construction and method of operation

operation adds a little more iron to the "body," as does friction on the piping to press, etc.

Reverting to the materials used in manufacture, ball clay and stone as used in earthenware, are contaminated with natural iron in varying degrees, so that, of ten specimens heavily contaminated can prove too much for the most efficient of magnets, and, since the first cost is negligible in relation to the goods produced, no effort or expense should be spared in installing magnet systems.

There are, of course, black specks of foreign matter also encountered in the materials used which are not iron, but those visible to the naked eye can be removed by the fine mesh lawns on the sifting systems. This is mentioned because often a manufacturer will think his magnets are not efficient if his sifting lawns are only 150 gauge or less, higher gauges are needed to remove foreign matter if visible size magnetted or otherwise.

More than one Point of Attack

Coming now to the magnetic systems available and recommended, it is to be mentioned that every unit used in the magnetting operation is having to break up the molecules of the constituents and sort out the iron, so that more than one point of attack is necessary. Any attempt to do the complete job at one point and with one magnet system would involve considerable bulk and weight.

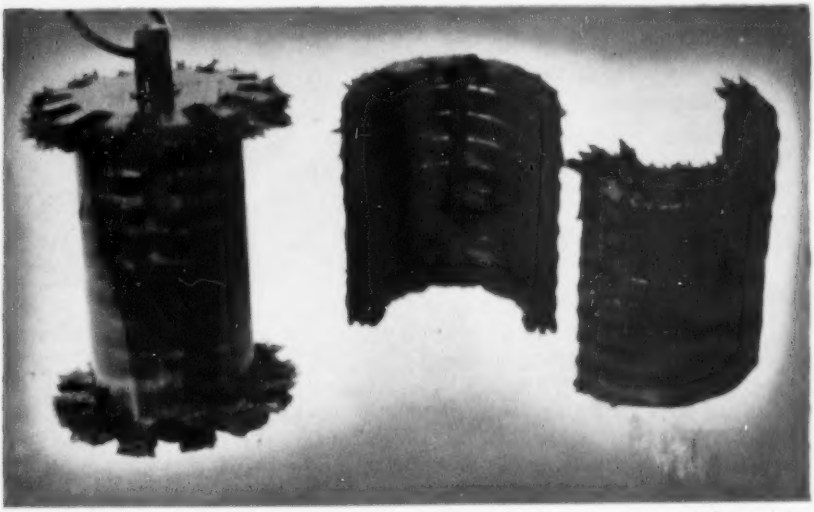
The electro-magnet manufacturers fully appreciate this point by attempting to provide the solution at one stage.

For reasons which follow a

The funnel filter, for use in the pottery industry

suitable installation in a normal factory with a high output, i.e. the larger type of manufacturer would be a large electro-magnet followed by a "policeman" permanent magnet such as the Philips 7711/03, then a Line Filter at the entrance to each press, to take care of the final pumping operation and pipe scale.

Thus, three points of filtration (magnetic) are provided, and under such circumstances among the highest quality ware is produced in England, whilst little or no trouble is ever experienced.



The magnet on the left and the two cages on the right have been removed from the outer casing of the filter for cleaning. Trapped contamination can be clearly seen

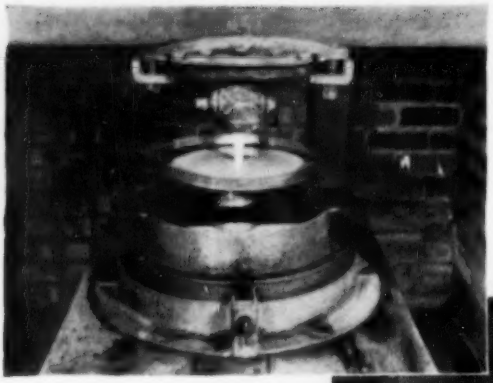
Where no electro-magnet is desired, for a large concern, two stages of the 7711/03 would be recommended, plus the usual filter on the press. There are many cases, of course, where the single 7711/03 plus press filter would suffice, but care would need to be taken by frequent cleaning after each "mixing."

Reasons for Permanent Magnets with Electro-Magnets

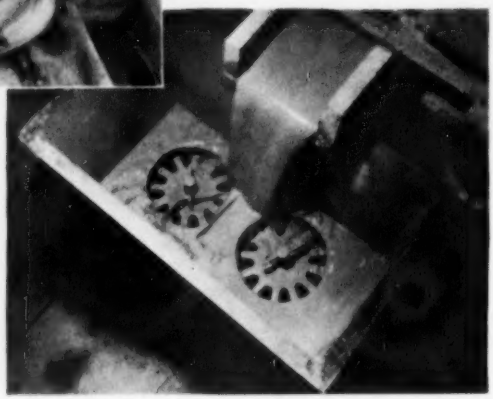
A manufacturer who has purchased and installed an expensive electro-magnet might well ask why further magnets are necessary at all, but these have been found to be so in practice for the following reasons:

Anyone who has picked up a cluster of iron filings with a simple magnet will have noticed how easily the outer layers will shake off with the slightest vibration, and only those closest to the magnet will remain on the face, despite attempts to remove them by shaking.

Now, an electro-magnet has a multiple of small projections over which the pottery "slip" flows, and these gradually build up with a bunch of iron particle and the bigger they become, the more resistance they offer to the flow of the "slip," with the result that, even with a constant flux density in magnetism there arises a "build up," a partial washing off, etc. The length of the magnet is designed to provide subsequent projections to catch the iron washed off the previous magnets but, in practice once all projections have their quota of "firmly held iron" the lighter held bodies of iron washed off at any point are carried right through into the mixing arc.



(Left) A vitreous enamel mill at the Cannon Iron Foundries Ltd., on which a magnetic filter is installed



Pottery "slip" flowing into a funnel type filter. This equipment has recently been installed at the Stoke-on-Trent works of Morley Fox and Co. Ltd.

This can be proved and illustrated every day in practice. It is an unfortunate fact that, say 20 particles of iron spread over a few gallons of slip, if separate, could pass unnoticed in "firing," but having been gathered together by a magnet, and, clinging together magnetically, they ultimately provide a flaw in a piece of ware. Variation of mains voltage will, however, often cause fluctuation in the efficiency and flux density of an electro-filter.

A "policeman" permanent magnet after any electro-magnet is, therefore, very sound practice, and the quantity of iron collected there has astonished many a manufacturer.

It will be observed from the construction of the Philips Permanent Magnetic filter that the method of magnetting is by concentrating the flux into a series of air gaps in the trapping cages.

Now, it will be readily seen that as the contamination builds up on the edges of these gaps, the flow of liquid slip tends to push the iron obstruction into the inside of the gap, instead of knocking it off, thus offering greater efficiency.

This efficiency is maintained until all gaps have been filled up, so that the trapping space is saturated.

It is for this reason that two large filters in series are recommended in a large works, where the total contamination likely to come out of one complete "mixing" may prove too much for a single unit.

In making a "magnetting" installation it is wiser to over estimate the contamination than to try to work on the bare minimum. In one case you will get consistently flawless goods, and in the other a periodical "break-out" of spoilt ware, where constituents have been contaminated above the average. The above remarks have applied mainly to the

body and slip of pottery manufacture, but the glazes must also not be overlooked.

All glazes are contaminated and should be "magnetted" in preparation for delivery to the dipping tubs. Philips type 7711/01 or 7711/02 are suitable for this purpose.

In the case of "casting slip" piped to various casting points, filters should also be placed in the feeding pipes. This is common practice in England and the contamination from pumping and piping collected therein soon convinces the user of their value. The filter at the entrance to the press, i.e. the Philips 7717/04 should be cleaned every time the press is cleared.

CLAYWORKING MACHINERY

UNDER the above title we have received the 14th Edition of a catalogue issued by Bradley and Craven Ltd., Wakefield. An interesting introduction shows the gradual extension of their factory from unpretentious beginnings in 1843 to present day, whilst mention is made of the "After Sales Technical Service."

The book is divided into eight sections dealing respectively with Grinding and Tempering Mills; Stuff Plastic Brickmaking Machinery; Plastic Brickmaking Machinery; Cutting Tables; Tilemaking Machinery; Pipemaking Machinery; Brick Presses; and miscellaneous plant for the brick, tile and sanitary pipe making industries.

Each different machine is pictorially illustrated, whilst general arrangement line drawings describe many articles of equipment. Specification details including output, power requirements, overall sizes and shipping weights complete the descriptions.

1951 Festival Display.—It has been decided that an exhibition of the pottery industry shall be held at the King's Hall, Stoke, during the first two weeks of June next year. The British Pottery Manufacturers' Federation have also agreed to co-operate in the organisation of an exhibition of modern pottery for a lengthy period at premises proposed to be erected on the Bell Pottery site, Hanley.

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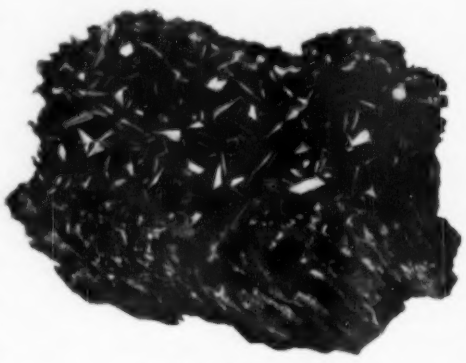
THE ROMANCE OF CARBORUNDUM

by

FRANK HARRIS
The Carborundum Company Limited

ANYONE familiar with the modern grinding machine in all its present day excellence may be pardonably surprised to learn that its capacity for grinding within almost incredible limits is the result of many centuries of painstaking trial and experience.

The art of grinding has its roots deep in antiquity, and we find reference to its importance in the old Testament. Certainly so long as man has made use of metal, he has known the value of abrasives, since there is no lack of evidence that the primitive weapons of the early cave dwellers were sharpened on natural sandstones. As the use of abrasives progressed through the centuries, the grinding wheel came to be recognised more and more as an essential tool, until with the coming of the Industrial Age, sandstones were widely used, not only for sharpening tools, but for finishing forgings and castings, and for the polishing of non-metallic materials, such as glass. Nowadays the part played in finishing by the manufactured abrasives, silicon carbide and fused alumina cannot be overestimated.



Carborundum crystals

Modern Usage

The largest users of the newer abrasives are the various metal industries. This was equally true in earlier days, although the natural sandstones could not be compared with what we think of as the modern grinding wheel. The sandstone user was compelled to take exactly what nature provided, and it was impossible to control the hardness of the stone or the size of the grit. These two factors are, of course, rightly considered essential for high precision work such as is required at the present day.

To a great extent, it was this uncertainty of hardness and grit size, which was largely responsible for the long delay in the development of the modern grinding wheel at a reasonable price, and it was not until the arrival of a genuinely satisfactory wheel, that mass production became reality. Mass production depends for its success on the ability of operators to perform their allot-

ted task not only quickly, but with sufficient accuracy that the various parts may be assembled without recourse to laborious hand-fitting.

Tracing back the history of the grinding wheel as a precision tool, we find that it helped industrial production in three ways:— the use of hard fast-cutting tool steels became practicable; the carefully made grinding wheel enabled the production of work to much greater tolerances than was hitherto possible with finer finishes as a matter of course; lastly, machine tools became far more accurate, due almost entirely to the skilful use of grinding.

The 1860's saw the development of emery wheels, which, although a distinct advance on the earlier sandstones, were crude when compared with the modern abrasive wheel. It is interesting to notice in passing that even to the present day the term emery wheel is still loosely employed to cover all grinding wheels, in spite of the fact that the number of emery wheels in present-day use is negligible. Emery, of course, is a natural product, and its superiority to the earlier sandstones is principally due to its ability to cut faster. The principal cutting or grinding constituent of emery is the mineral corundum, which as a natural product is only exceeded in hardness by the diamond itself. Corundum occurs in various forms including the precious stones ruby and sapphire. As industry progressed, the need for a more efficient abrasive at a low cost was realised, and the search for a suitable manufactured abrasive began.

Important Discovery

In the year 1891 the American scientist, Edward Goodrich Acheson made a discovery which is now rightly regarded as of paramount importance in the progress of industry. He tried fusing clay with carbon in the electric arc and produced some microscopic crystals which sparkled like diamonds. He found that these crystals were so hard that they would cut glass. He was able to produce them in quantity by various modifications of the process after devising and building a suitable furnace. The original furnace consisting of a few bricks capable of producing only 4 oz. a day was the forerunner of the giant furnaces of today.

Properties

The new substance was beautiful in appearance, but the vital question was, was it useful? A study of its properties showed that it was intensely hard, and sharp, and infusible at any known temperature. These properties suggested that it was peculiarly adapted for abrasive or grinding purposes, and also as a highly refractory material. But for abrasive purposes the world already used emery at a cost of less than 2½d. per lb. and refractory material in the form of fire clay cost less than £2 per ton, whilst the cost of the new substance ran away up into pounds per lb.

Acheson coined the name "Carborundum" for his material which was found to be actually silicon carbide. It could only be used for such purposes as the polishing of precious stones where the high cost was justified. Acheson found that the prevailing price for diamond powder, then used for polishing gems, was 3s. per carat, or over £300 per lb. He very carefully graded a quantity of "Carborundum" powder, put it into a homeopathic vial, and with the world's entire supply in his vest, set off to interview the gem cutters of New York. The jewellers smiled sceptically but were coaxed into trying the new substance. It did the work. Acheson carried home an order for 10 carats of Carborundum powder at 1s. 8d. a carat; and on the strength of that first order, one of the greatest of the present-day abrasive manufacturers was organised.

Improved methods still further

increased the output, until the market was glutted and the price was hammered down until it reached the minimum of 10d. a carat, or only £176,000 per ton! This reduction in price broadened the market to some extent, but with 4 oz. coming into the world every day, the stock of silicon carbide continued to grow rapidly, and decided action was necessary.

It was found that the operation of valve grinding could be performed in but a small fraction of the accustomed time if "Carborundum" was used. Accordingly it was sold for this purpose at the introduction price of 40s. per pound. The purchasers kept a 1 or 2 lb. tin of powder in the office safe, and weighed out small quantities to the shop foreman on requisition.

Other Abrasives

Not long after the epoch-making discovery of "Carborundum" by Acheson, an American scientist named Jacobs, found a commercial method for producing fused alumina, another abrasive, which is now used on a very large scale, for the grinding of steel, and in fact all high tensile metals. It is made by electrically fusing a highly aluminous clay called bauxite, and is in fact synthetic corundum, sold under various trade names such as "Aloxite." Since those early beginnings, the use of manufactured abrasives in industry has attained enormous proportions, and it is no exaggeration to claim that mass-production, as it is now understood, could hardly have been possible without their aid. The days are long past when an abrasive was merely something to wear away metal, and a modern abrasive wheel is easily capable of grinding to within limits of one twenty-thousandth part of an inch. It is, indeed a precision tool and demands not only a high degree of scientific control in manufacture but skill in its operation.

A more recent and highly interesting abrasive development is to be found in the use of bonded diamond abrasive grain. Originally introduced to meet the demand for greater speed and production, higher accuracy and perfection of finish for the grinding of tungsten-carbide tipped tools, the application of Carborundum Brand Diamond Products has extended into many other fields. The ability of these products to maintain form and size has rendered them of invaluable assistance in the accurate shaping of tungsten-carbide form tools, the internal grinding of tungsten-carbide dies, the honing of nitrided and other very hard bores. Applications in the glass trade include the forming of lenses, surface grinding of optical glass, condensers, etc., trepanning and drilling of optical and plate glass and the rapid production to close limits of glass joints in laboratory glass ware.

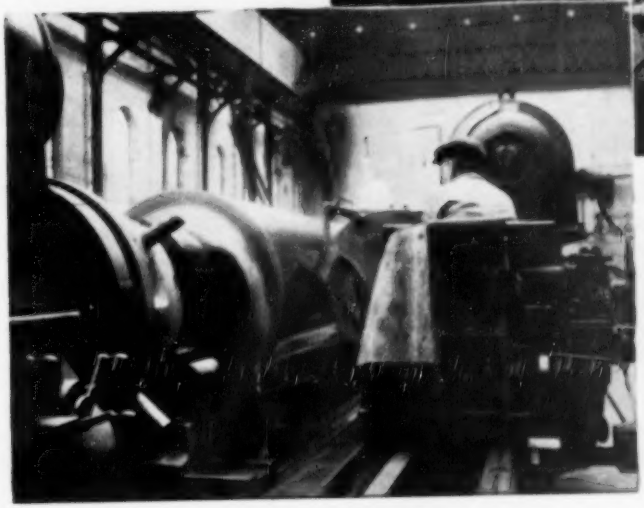
Wide Use in Industry

It is difficult to think of an industry which makes no use of this manufactured abrasive in some form or other. From the scythe and mower knife of the Somerset farmer to the harpoon of the Labrador whaler, the hard, fast-cutting grains find a job to do, and they do it as no other substance has ever been able. You can see them sparkling in the floors of the Underground stations, where they have been embedded for non-slip purposes. In certain hospitals you can find queer-shaped stones of silicon carbide for the scraping of human bones. There is even a famous illusionist who has found a use for it in his mission of mystification, though even the Carborundum people have never been able to discover just how he applies their product to his peculiar needs.

Modern refractories are the results of more than 100 years of development in the manufacture and application of refractory materials. New and improved refractories have been

(Left) Showing the operation for edging mirrors with a grinding wheel

(Right) Sharpening a tungsten carbide lathe tool with a diamond abrasive wheel



(Left) Grinding a large roller. Note the mirror finish obtained by the use of a grinding wheel

Silicon carbide kiln furniture in use for firing domestic earthenware

produced as conditions of refractory use became more severe. Many industrial processes now in use have been made possible only because of the development of improved types of refractories, that is to say super-refractories.

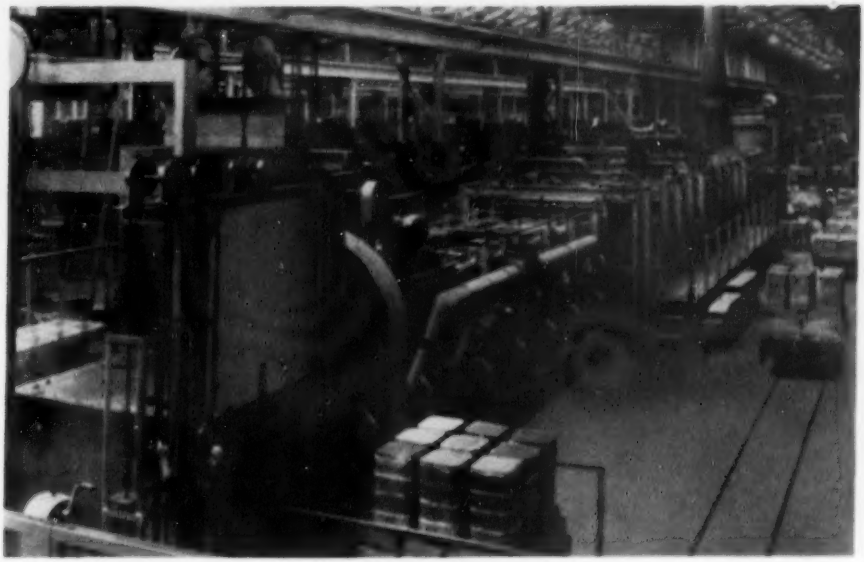
It was early recognised that "Carborundum" (silicon carbide) and "Aloxite" (fused aluminium oxide) were important as refractory materials in addition to being superior abrasives.

Owing to the outstanding properties of silicon carbide, such as its high thermal conductivity and low co-efficient of expansion, refractories made from it, possess the ability to withstand temperature changes to a remarkable degree, as well as transmitting heat very efficiently and standing up to very high temperatures.

Ceramic producers are turning more and more to the use of silicon carbide kiln furniture. In this field, the benefits of the material are well known, for example, its thermal conductivity (about 10 times that of fire clay) means more rapid and uniform heat flow to ware. Furthermore, at elevated temperatures, its load carrying strength is exceptionally high.

These several properties of silicon carbide have led to its recognition as a super-refractory of exceptional merit, and it is today finding extensive use for a great variety of furnace applications. The development of "Carborundum" brand refractories for a wide range of uses including melting non-ferrous metals in special crucibles has been brought about as the result of many years of research and practical trials.

Continuous POTTERY KILNS



Illustrated is an Incandescent oil fired tunnel type kiln installed for the production of electrical ceramics. This unit has an output of 10 tons per week.

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Applications of Glass Linings in Chemical Process Plant

THE increasing application of glass enamelled steel and cast-iron is resultant upon great strides made in the development of this type of constructional medium. Whilst the field is far from fully explored, more recent experience enables bolder application to be envisaged.

Consideration of a constructional material for chemical plant manufacture usually embraces the following points and the object of this article is to consider these points in the light of present day knowledge of glass enamelled equipment.

(*a*) *Strength and ease of fabrication.*

The ultimate strength of a glass enamelled vessel is that of the base metal. After coating, further fabrication in the form of welding, drilling, etc., cannot be performed.

(*b*) *Chemical Properties.*

Generally speaking, chemical-resistance glass has a very wide range from highly acidic conditions to alkaline conditions of the order of a *p*H of at least 10.

(*c*) *Temperature Limitations.*

The softening point of good chemical enamel is over 500° C., and the lining may be used up to 300° C. working temperature.

(*d*) *Pressure Limitations*

These are dependent upon the strength of the base metal. The thickness of the vessel must be such that deformation under strain conditions is within the elasticity of the enamel coating. Perfect success is achieved under conditions varying from 27 in. vacuum to 120 lb. per sq. in. (in some cases up to 200 lb. per sq. in.)

(*e*) *Contamination of Product.*

This may be due to corrosion (mild or severe), abrasion or merely surface contamination arising from cleaning difficulties. Abrasion resistance of chemical glass enamels is of the order of 5-6 on MOH of scale of hardness.

Glass enamelled steel and cast iron are structures of these materials on which is fused a coating, 0·010-·060 thick, of a true glass of the boro-silicate type. Manufacturers keep their composition more or less a secret but all these materials are essentially boro-silicates with fluoride and alumina additions to improve the processing properties. Nickel, cobalt and manganese are used to colour the cover coat whilst similar additions in ground coats tend to improve the adherence to metal. Additions of titanium improve the ability to withstand thermal shock, and along with silicate to increase resistance to acid attack. Glass enamels are made by smelting together such materials as borax, sodium chloride, soda ash, fluorspar, fluorides, oxides, etc., to form a molten glass which is poured into water to produce a frit. The frit is milled either wet or dry depending upon the process to be used when applying it to the structure (by spraying or dusting).

Table I shows clearly the chemical composition of a ground coat and two cover coat enamels prior to smelting. At the bottom of the table the mill additions are given which, when ground together in a mill produce the final slips for spraying.

CERAMICS abstract of a paper by H. D. MacMurray and J. D. Currie presented at the recent Conference, Materials of Construction in the Chemical Industry, held in Birmingham by the Society of Chemical Industry.

TABLE 1

TYPICAL FRIT BATCH COMPOSITIONS

Raw Materials	*Ground coat*	*No. 1 chemical resisting cover coat*	*No. 2 chemical resisting cover coat*
Quartz	24 80	43 50	39 00
Felspar	32 50	—	—
Borax	25 00	26 70	18 50
Fluorspar	4 20	2 50	3 00
Sodium carbonate	6 80	7 00	—
Sodium nitrate	4 60	2 50	2 50
Cobalt oxide	0 50	1 00	1 00
Nickel oxide	0 60	—	—
Manganese dioxide	1 00	—	—
Titanium dioxide	—	14 00	10 50
Cryolite	—	2 80	1 50
Sodium silicate	—	—	24 00
Mill Additions			
Frit	100 00	100 00	100 00
Quartz	10 00	—	—
Clay No. 1	3 00	3 00	2 00
Clay No. 2	3 00	3 00	3 00
Clay No. 3	6 00	—	—
Sodium nitrite	0 125	—	—
Magnesium carbonate	0 375	—	—
Borax	0 750	0 125	—
Potassium chloride	—	0 250	0 125
Water	31 00	30 00	25 00

In the case of dry processing, frit particles are ground into a fine powder.

Three Techniques

From the flow sheet in Fig. 1 it will be seen that there are three main enamel techniques; "A," "B" "C."

A and B processess are for chemical equipment proper whilst C is mainly for storage tank work, where there is a demand for cleanliness, appearance and resistance to mild chemical acidity. In practice there is a considerable amount of overlapping (especially with process C) to meet requirements of individual items and equipment.

Keeping the three processess in mind we can now consider the flow sheet more closely. This chart does, in point of fact, relate to the process using Mild Steel as the base material but the principle is very similar in Cast Iron technique. It should be mentioned that Cast Iron processing is mainly confined to the A process with acid-resisting enamels of a high order.

After initial fabrication all internal welds are ground flush and the tanks then passed to furnaces for normalising or stress relieving of the welds. This also burns out any oil or grease deposited inside the vessel.

A stage of sand-blasting now leaves the tank ready for the ground coat (in all three processes ground coats are sprayed). After this the tanks are dried by hot air, this being procured from recuperators on the furnaces in the main shop. When the tanks are furnaced at 900° C. and in the case of processes B and C the vessel is cooled and inspected before the first cover coat is applied. There is practically no difference between processes B and C except that in the former, in addition to the sprayed slip, a liberal dusting of dry powder is given to the vessel immediately after spraying.

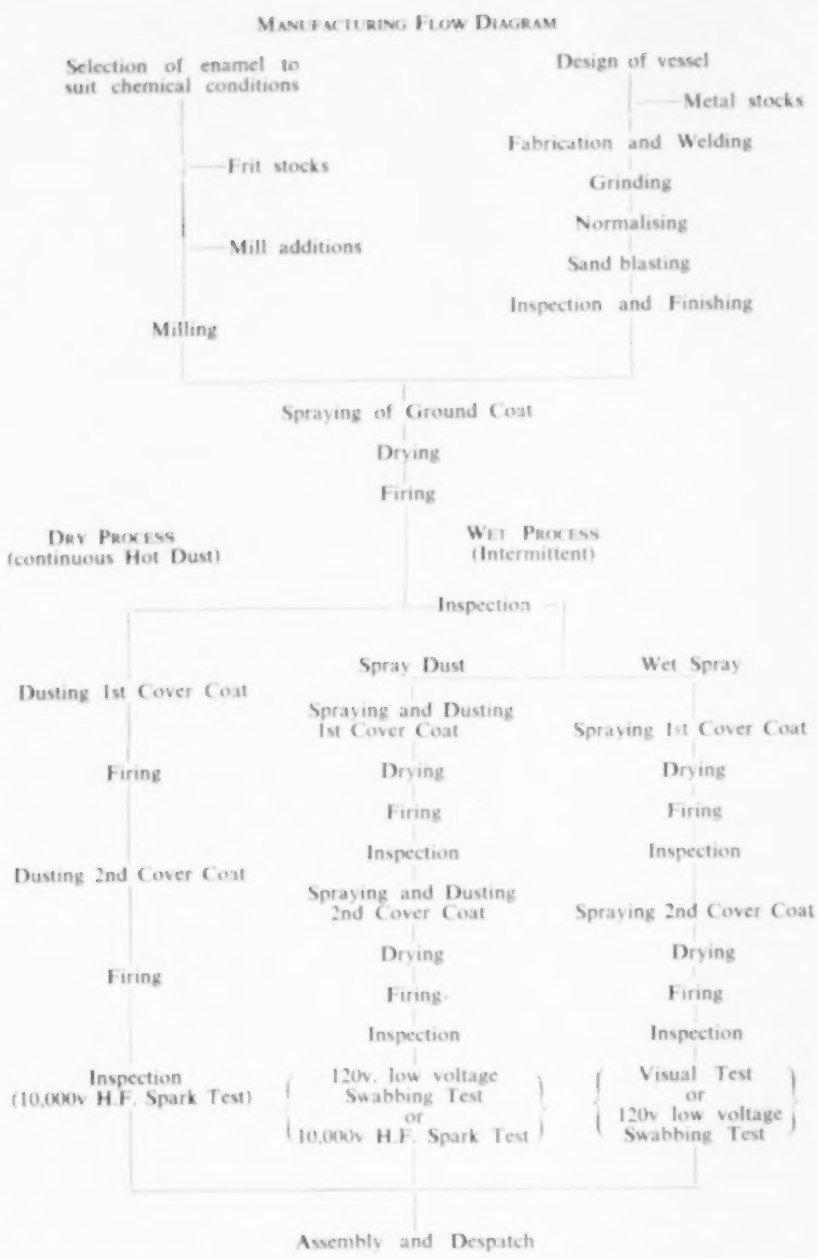
MANUFACTURING FLOW DIAGRAM
Selection of enamel to suit chemical conditions
Frit stocks
Mill additions
Milling
Design of vessel
Metal stocks
Fabrication and Welding
Grinding
Normalising
Sand blasting
Inspection and Finishing
Spraying of Ground Coat
Drying
Firing
DRY PROCESS (continuous Hot Dust)
WET PROCESS (Intermittent)
Inspection
Spray Dust
Wet Spray
Dusting 1st Cover Coat
Spraying and Dusting 1st Cover Coat
Spraying 1st Cover Coat
Firing
Drying
Drying
Firing
Firing
Inspection
Inspection
Dusting 2nd Cover Coat
Spraying and Dusting 2nd Cover Coat
Spraying 2nd Cover Coat
Drying
Drying
Firing
Firing
Firing
Inspection
Inspection
Inspection (10,000v H.F. Spark Test)
120v. low voltage Swabbing Test or 10,000v H.F. Spark Test
Visual Test or 120v low voltage Swabbing Test
Assembly and Despatch

Fig. 1

Two cover coats are generally given after which inspection and electrical tests are carried out.

Process A is a dry dust process and differs mainly in that it is continuously applied with no intermediate cooling, drying and inspection stages. The vessels are taken from the furnace at 900° C. and whilst still red hot are dusted on a turn-table, the powder being applied by a readily controllable air-vibrated sieve. The vessel is then re-charged into the furnace where it is heated up to the enamel's fusion point. The two cover coats may be applied in similar fashion. Process A is the quickest, and the only reason for all chemical vessels not being treated in this way is that of awkward handling arising of certain shapes and larger sizes.

Checked Electrically

Finished articles are all checked electrically, the test being really one of insulation value. In process A and B tests of 10,000 volt pressure are applied. In process B there is an alternative 120 volt swabbing test. Process C usually undergoes the 120 volt test but from previous remarks it will be appreciated that the stringency of inspection in this instance depends on subsequent service conditions. For example, in the case of storage conditions where there is little corrosive action to be expected, minor visual inspection suffices.

Maximum capacities of vessels which can be lined by the three processes are as follows:-

(1) "A" up to 500 gallons.
(2) "B" up to 600 gallons.
(3) "C" up to 10,000 gallons.

These refer only to single shell vessels. In point of fact, vessels up to 18,150 gallons have been made by joining sections together.

Types of equipment handled are many and varied—open and closed, horizontal or vertical, jacketed vessels either for heating or cooling, agitation equipment, and accessory items such as pipes, valves, etc.

Where necessary agitation can be provided by agitators and baffles having glass coating similar to that lining the vessel whilst in the accessory range, fittings, pipes and even pumps may be obtained in glass enamelled steel or cast iron.

Design of Equipment

In the successful enamelling of a vessel probably as much is due to the initial design as to the art and technique of the enameller. For this reason most manufacturers of glass-enamelled plant have developed a series of standard units and fittings. Factors governing these designs may be summarised as follows:-

(1) The necessity for a uniform thickness of metal throughout each separate part of the unit as far as possible.

(2) Avoidance of all heavy lugs, brackets, bosses, etc., in order to eliminate local strain in the coating

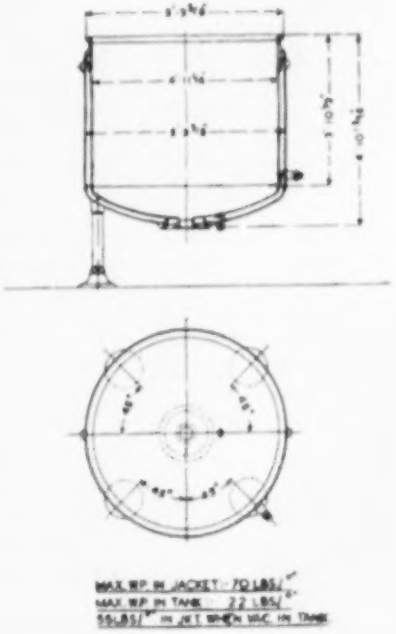

Fig. 2

due to retention of heat by these thick sections during cooling

(3) All curved surfaces to be such that their curvature is greater than a certain specified minimum radius (in practice approx. $\frac{7}{16}$ in.). The number, design and position of nozzles and branches in the body of the vessel must be carefully considered.

(4) The avoidance of over-size openings to obviate distortion at the high process temperatures.

Fig. 2 shows salient design points. Had the normal design technique for mild steel vessels been followed (i.e. with right-angled flanges), difficulty would be encountered due to the fact that a square edge on the inside of the flange tends to cause the liquid enamel to flow away and expose the metal at the corner. In the standard design, the flange is given a gentle sweep.

Bubble Structure

It is generally accepted that a bubble structure is advantageous provided it is fine and uniform. By emulating to a certain degree controlled composition technique as employed for optical glasses, very high standard enamels can be made. Bubble structures fall mainly into three classifications:-

(1) Inherent bubbles produced by gas evolution from frit batch materials.

(2) Gas evolution from the base metal caused by inclusions, or by lack of proper cleaning.

(3) Reaction between coats of different compositions. Mill additions also increase bubble structure and must be carefully balanced.

Heat Transfer

Overall coefficients vary so much in individual cases that a definite figure is impossible. The rate of heat transfer is dependant on the thickness of the enamel coating. This can be controlled within reasonable limits but not sufficiently close for accurate heat transfer figures. The following information is based upon a large number of installations:-

Glass lined steam jacketed vessels for heating and boiling may be expected to give 70-80 B.Th.U/per sq. ft./° F. for water, but for certain organic liquids this figure may be as low as 60-70. For cooling and condensing the respective overall coefficients would be of the order of 40/50 and 35/40 with water in the jackets.

Actual values will, of course, vary with each installation, but the above figures form a useful practical guide.

Chemical Durability

Despite the fact that glass enamel is not regarded as ideal for strongly alkaline conditions it does offer reasonable resistance, and many plants, operating under exceptional alkaline conditions, are giving very good service. Glass linings can be used with every confidence in cases involving neutralisation especially by any strong caustic alkali provided the alkali is added with due care, i.e., slowly, with agitation and in the body of the liquor to be neutralised, i.e., as far as possible from the glass lined surface. Sometimes, to meet heavy-alkaline duties, glass-thickness is increased to improve durability. This applies mainly to process "A" equipment.

Since the linings are of borosilicate glass, acid resistance is high. The range of allowable acid and alkaline conditions is such that vessels may be used for a number of processes within limits of durability without detriment, an extremely useful property where floor space is vital.

One special form of corrosion occurs under atmospheric conditions where hydrogen is liable to be formed on the outer metal surfaces. This hydrogen then diffuses through the metal wall and causes rupture of the enamel. Such conditions demand regular painting of equipment.

Applications

Examples of typical equipment treated by these methods include surface condensers, jacketed reaction vessels with impellor-type agitators (Process A), distillation units, rotary crystallisers (Process C) evaporating pans, etc.

Chemical Engineering duties performed by glass line vessels include handling of such products as phloroglucinol, o-tolyl thiourea, sodium cyanate, etc. Reactions involved include chromic acid oxidation in the presence of glacial acetic acid, reaction of glycerol with fuming hydrochloric acid at 100° C. and the production of such materials as insulin solutions and penicillin. Glass enamelled equipment has given satisfactory service with such corrosive materials as phosphorous halides, thionyl chloride, etc., in non-aqueus or non-hydroxylic conditions.

In one process, where initial reaction requires the presence of ·880 ammonia, the glass lining stands up well, and though there is a certain surface etching of the glass, no appreciable shortening of the vessel's life results.

COBALT NICKEL AND SELENIUM IN POTTERY

THIS new publication written by H. W. Webb, O.B.E., D.Sc., F.R.I.C., M.I.Chem.E., and published by the Mond Nickel Co. Ltd., Sunderland House, Curzon Street, W.1, provides widespread interest. It deals with the history and uses of cobalt and the use of cobalt compounds in the production of white pottery bodies. Staining of glazes, cobalt under-glaze colours, silicate blues, flow blue and cobalt aluminate are dealt with.

Information is given on the uses of nickel and selenium. There is an outline of the colours obtainable by the combination of cobalt oxide with the oxides of zinc and aluminium and of those obtainable by combining nickel oxide with those of zinc and aluminium.

Typical analyses are given for cobalt oxides and salts.

A most interesting inclusion is a comprehensive list of references on the subjects.

Copies of this publication are available from the Mond Nickel Co. Ltd.

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The Fine Ceramics Industry in Germany

During the Period 1939—1945

THIS B.I.O.S. survey is report No. 28 issued as a British Ceramic Research Association special publication No. 3 by D. A. Holdridge and available from H. M. Stationery Office at 3s. 6d.

In Part I there is a comprehensive description of the growth of the German Industry and its location. Table 1 outlines the number of factories existing in 1939 in their various categories, whilst Table 2 indicates the position in 1925.

A description is given of the central organisation of the German ceramic industry and reference is made to a standard costing and account system used in all branches of the ceramic industry. Production figures for these products during the years 1939-1944 are given in Table 3, whilst Tables 4 and 5 show the distribution of labour in the industry in 1939 and 1925.

Starting wages and piece work rates are available as well as the hourly rates of pay in different parts of the process. A special point is worth noting in so far as facilities for technical education in the industry is concerned. Sources of instruction included the universities, the colleges and special scientific institutions. At the lower level there were ordinary technical colleges and mining academies and for a long time the leading German technical colleges conducted special departments to studying silicate chemistry in general and ceramics in particular. Examples are the Technical High Schools at Berlin, Dresden and Munich. Special ceramic schools

TABLE 1

NUMBER OF FACTORIES IN VARIOUS BRANCHES OF CERAMIC INDUSTRY, 1939

Household and Decorated Porcelain (including *Porelit*)	176
Dental Porcelain	9
Household and Decorated Earthenware and Fine Stoneware	101
Pottery	213
Electro-technical, Technical and Chemical-technical Products made from Ceramics	138
Sanitary Ceramics	33
Ceramic Tiles	42
Oven-Tiles and Structural Ceramics	172
Abrasives	152
Total	1036

TABLE 2

NUMBER OF FACTORIES IN VARIOUS BRANCHES OF CERAMIC INDUSTRY, 1925

(a) Porcelain	1256
(b) Earthenware and Majolica Ware	110
(c) Stoneware	222
(d) Oven-Tiles and Pottery	1413
(e) Floor and Wall-Tiles	42
(f) Combined Works	23
Total Fine Clay Ware Products Industry	3066

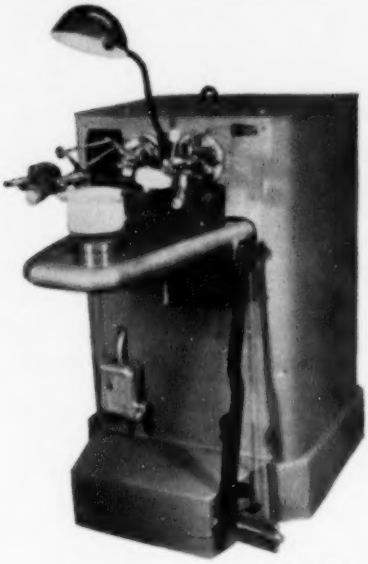

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TABLE 3

PRODUCTION OF CERAMICS IN GERMANY 1939-44 (metric tons) (after Warde) [117]

Production Group	1939	1940	1941	1942	1943	1944
I. Household and decorative porcelain ...	79,172	69,621	56,020	50,684	51,134	54,391
II. Household and decorative earthenware ...	48,163	41,586	36,965	34,977	41,027	42,567
III. Pottery	52,292	54,555	59,166	51,158	53,951	45,629
IV. Technical porcelain	51,133	54,968	61,338	64,042	61,934	65,236
V. Sanitary ware	42,480	38,876	38,822	34,180	32,644	21,980
VI. Floor and wall-tiles ...	290,819	203,757	201,877	118,328	76,665	42,790
VII. Oven-tile and structural ceramics	78,897	68,482	81,432	53,502	67,448	70,993
VIII. Abrasives	45,485	48,331	52,291	55,225	59,128	54,231
	Rm.	Rm.	Rm.	Rm.	Rm.	Rm.
ID. Dental porcelain* ...	8,095	8,813	9,827	10,876	11,085	13,136

*Production of dental porcelain is given in 1,000 Rm. at pre-war rate (approx. £1 = 12 Rm.

TABLE 4

DISTRIBUTION OF LABOUR IN CERAMIC INDUSTRY, 1939

Section	*Productive workers*			*Office staff etc.*	*Total employed*	*non-productive staff*
	Total workers	*Male*	*Female*			
I. Household porcelain ...	39,057	18,623	20,434	4,488	43,545	10·3
ID. Dental porcelain ...	1,145	163	982	187	1,332	14·0
II. Household earthenware	12,439	6,539	5,900	1,460	13,899	10·5
III. Pottery	2,784	1,852	932	464	3,248	14·3
IV. Technical ceramics ...	13,876	7,234	6,642	1,916	15,792	12·1
V. Sanitary ceramics ...	5,326	4,607	719	550	5,876	9·3
VI. Ceramic tiles	12,277	7,941	4,336	1,180	13,457	8·7
VII. Oven-tiles and structural ceramics	5,765	4,916	849	699	6,464	10·8
VIII. Abrasives	5,879	4,698	1,181	2,052	7,931	25·9
Total	98,548	56,573	41,975	12,996	111,544	11·6

TABLE 5

DISTRIBUTION OF LABOUR IN CERAMIC INDUSTRY, 1925

Section	*Total number of persons employed*
(a) Porcelain	70,818
(b) Earthenware and Majolica Ware	16,902
(c) Stoneware	4,315
(d) Oven-Tiles and Pottery	13,175
(e) Floor and Wall-Tiles	7,983
(f) Combined Works	3,013
Total Fine Clay Ware Products Industry	116,206

such as the one at Höhr established in 1928, have trained more than 500 ceramists and that at Bunzlau had become world famous and trained some 750 ceramists.

It is pointed out that the training of apprentices in the German industry was thorough. For example, in the porcelain industry pre-war, it was 4 years for factory workers and 3 for painters. In so far as the Decorators' Course, in 1937 there were detailed schemes for training painters, modellers, figure makers and makers of technical ceramics. For example, the compulsory standard to be reached by an apprentice included the knowledge of and critical examination of

TABLE 6

ESTIMATED RAW MATERIAL AND FUEL INTAKE AND OUTPUT FOR 1942

(1,000 metric tons)

Section of Industry	Raw Materials Intake				Fuel Intake				Total raw material and fuel	Output	% of (a) Total intake (b) Body materials
	Kaolin	Clay	Misc. materials	Total	Coal	Brown Coal	Brown Coal Briquettes	Total Fuel			
I. Household porcelain, decoration plants and dental porcelain	68	115	70	253	103	279	68	450	703	76	(a) 10·8 (b) 30·0
II. Household earthenware and fine stoneware	37	64	27	128	52	63	100	215	343	48	(a) 14·0 (b) 37·5
III. Pottery	—	87	3	90	25	10	45	80*	170	62	(a) 36·5 (b) 68·9
IV. Technical Ceramics	40	52	56	148	50	70	130	250	398	70	(a) 17·6 (b) 47·3
V. Sanitary Ceramics	13	60	22	95	80	32	80	192	287	47	(a) 16·3 (b) 49·5
VI. Ceramic Tiles	36	240	50	326	56	10	56	122	448	216	(a) 48·2 (b) 66·2
VII. Oven-Tiles and Structural Ceramics	6	80	20	106	5	22	68	95†	201	89	(a) 44·2 (b) 83·9
VIII. Abrasives	—	—	73	73	62	25	43	130	203	55	(a) 27·1 (b) 75·4

*Also 44,000 Rm. value in wood. †Also 106,000 Rm. value in wood.

TABLE 7

RATIO OF FUEL USED TO WARE PRODUCED

Industry	*Intermittent firing*			*Tunnel firing*		
	Coal/ware kg./kg.	*Temp. °C*	*Time firing and cooling (hr.)*	*Coal/ware kg./kg.*	*Temp. °C*	*Time firing and cooling (hr.)*
Porcelain tableware	3·20-4·00	1,410	76	1·43-1·71	1,410	28-40
Elec. porcelain insulators	2·07-2·37	1,410	80	0·95-1·25	1,410	90-100
Earthenware biscuit	0·85-1·00	1,280	72	0·20-0·23	1,280	27-37
Earthenware glost	1·00-1·80	1,150	72	0·30-0·34	1,150	17-30
Sanitary earthenware biscuit	1·20-1·45	1,280	86	0·49-0·62	1,280	34-50
Sanitary earthenware glost	1·40-2·10	1,100	76	0·50-0·63	1,100	23-36
Wall-tile biscuit	0·50-0·62	1,280	180	0·13-0·27	1,280	80-100
Wall-tile glost	0·40-0·48	1,060	160	0·24-0·35	1,060	30-50
Floor-tile	0·30-0·38	1,280	230	0·315-0·37	1,280	100-120
Fire Clay	0·20-0·23	1,300	110	0·08-0·10	1,300	70-90

the important ceramic colours, coloured glazes and precious metal preparations; the preparation of colours and precious metal mixtures; a knowledge of the mechanical painting process; stamping; spraying with and without stencils; centring; bordering; lining and banding articles of any shape; finishing; painting of letters and monograms; hand-painting of simple designs. Among the voluntary standards including the etching of porcelain; ground laying; painting of reliefs; polishing and engraving precious metal, enamels; hand painting of awkward designs such as flowers and ornaments; stencil cutting; pattern design; salting half finishing and finishing. Emphasis was made at the examination task on the practical aspect.

Thus it will be appreciated that importance was placed on a good practical knowledge of the particular branch chosen by the apprentice. An example has been given of the examination for a ceramics decorator, but in other branches the approach was similar.

Table 6 outlines the estimated raw material and fuel intake and output of the industry for 1942, and Table 7 shows the ratio of fuel used to the ware produced.

Of the 679 ceramic plants operating in Germany at the end of the war, they were distributed as follows:

British zone	84
American zone	164
French zone	162
Russian zone	269

whilst a more detailed breakdown of the distribution in the various zones of occupation is given in Table 8.

TABLE 8

PERCENTAGE DISTRIBUTION OF GERMAN CERAMIC INDUSTRY BY ZONES OF OCCUPATION

	Production Group	*Zone of Occupation*				*Polish territory*
		American	*British*	*French*	*Russian*	
I.	(a) Household Porcelain	66	1	—	25	8
	(b) Decorative Porcelain	56	4	—	40	—
	(c) Dental Porcelain	8	—	83	9	—
II.	Household and Decorative Earthenware	11	0·3	14	67	7
III.	Pottery	7	7	33	46	7
IV.	Technical Ceramics	28	1	—	63	8
V.	Sanitary Ceramics	18	37	13	14	18
VI.	Floor and Wall-Tile	6	5	25	42	22
VII.	Oven-Tile and Structural Ceramics	8	2	1	61	28
VIII.	Abrasives	20	57	4	19	—

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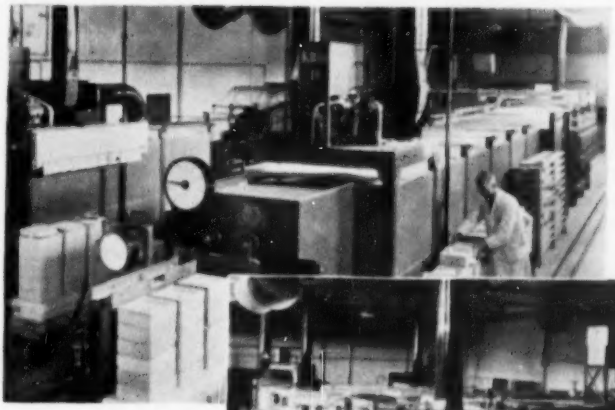

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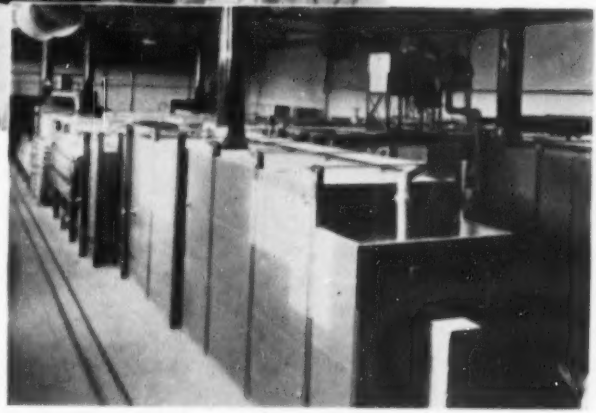

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In Part II there is a detailed description of the various aspects of ceramic production, including diagrammatic representation of the production flow, the raw materials and data on casting, drying, handling, firing, glazing, sorting, polishing and decoration for hard-paste porcelain, laboratory porcelain, dental porcelain, earthenware, stoneware and terra cotta. Technical ceramics, sanitary ware and ceramic tiles are reviewed in detail from the technical production process. Reference is also made to kilns, dryers and the various raw materials for the body, glaze and colours.

This is altogether a most useful survey of the German industry, co-ordinating some 139 reports and documents published by the various investigating agencies who have visited Germany since the war.

Correspondence

STANDARDISATION OF SIZES OF TUBES MADE FROM SPECIAL REFRACTORIES

DEAR SIR,

The Sintered Oxides Sub-Committee of the Inter-Service Metallurgical Research Council (Ministry of Supply and Admiralty) has held discussions with manufacturers with the aim of improving the supply of *tubes* of special refractory. At present, delay in the delivery of these items arises mainly from the large number of different sizes which are demanded by the users.

It has now been agreed to concentrate on production of a range of sizes which are to be regarded as standard henceforward. The sizes adopted have been chosen after careful consideration of the demand for tubes in recent years, and it is hoped that they will fulfil the requirements of most users. The manufacturers have undertaken to maintain stocks of the standard sizes, so that orders may be met from articles in stock.

The success of this attempt to provide better supplies of tubes will depend of course on the wholehearted co-operation of the users. In particular, those employing large numbers of tubes are asked to standardise their sizes at the earliest possible moment and those designing new apparatus are asked to use standard sizes wherever possible. Production of the standard items will commence immediately. Non-standard tubes will be obtainable, but their delivery may still be subject to delay.

Tube standardisation details are as follows:—

1. The materials involved are:—
   (i) Impervious alumina, and
   (ii) Impervious mullite for use at temperatures up to 1,700° C.

(The descriptions of the two classes of special refractory are those agreed by the manufacturers, who will provide details of the properties of their products on request).

2. The cross-sections of the standard sizes are:—

Internal diameter (mm.)	Wall thickness (mm.)
5	1·5
10	2·0
15	2·5
25	3·0
40	4·0
50	4·5
65	5·0
75	5·5

All tolerances will be as stated by the individual manufacturers.

(Metric sizes are adopted in view of the present trend in that direction and because many special refractory tubes are used in research, where the metric system is usual.)

3. All standard tubes will be available in lengths up to 900 mm. with both ends open, and also with one end open and the other hemispherically closed.

Thermocouple insulator. Whilst dealing with tube standardisation, the opportunity has been taken to introduce a standard cross-section of impervious alumina twin-bore thermocouple insulator. It will have:—

Oval section, with 3·5 mm. major, and 2·0 mm. minor axes;

1 mm. bores, 1·5 mm. between centres.

In conclusion, it must be emphasised that the full effect of standardisation will not be evident until the maximum possible number of users are able to adopt the new sizes and until the manufacturers are able to build up stocks. Neither of these processes can be brought about immediately, but it is hoped that the standardisation scheme will be working efficiently in the very near future.

J. P. ROBERTS,
Secretary,
Sintered Oxides Sub-Committee,
Inter-Service Metallurgical
Research Council,
Ministry of Supply and Admiralty,
Royal Aircraft Establishment,
Farnborough, Hants.

Moulded Refractory Burners and Tunnels for Industrial Purposes

by

W. N. SMIRLES, B.Sc., A.R.I.C., M.Inst. Gas E.

Development Officer, Industrial Department West Midlands Gas Board, Birmingham District

THIS paper gives an account of the design, construction and performance of a special type of moulded refractory burner to be used for local heating in industrial operations.

The burner consists of a short converging tunnel at the base of which theoretical air/gas mixtures are burnt. The flames are formed at the mouth of a series of slots in the base of the tunnel, which base is moulded integral with the tunnel walls.

The performance of these burners is gauged by the heat imparted to a circular water tube across the tunnel mouth and the results are related to standard data on forced convection.

A Paper read before the Midland Junior Gas Association, 28th March, 1950.

Introduction

In industrial operations occasions are often arising where local heating of a component is required. Such heating may take the form of a fusion as in glass manipulation or silver soldering, local softening or annealing as in metal fabrication, or heating prior to local hardening. Of necessity the Birmingham undertaking has always had a keen interest in this

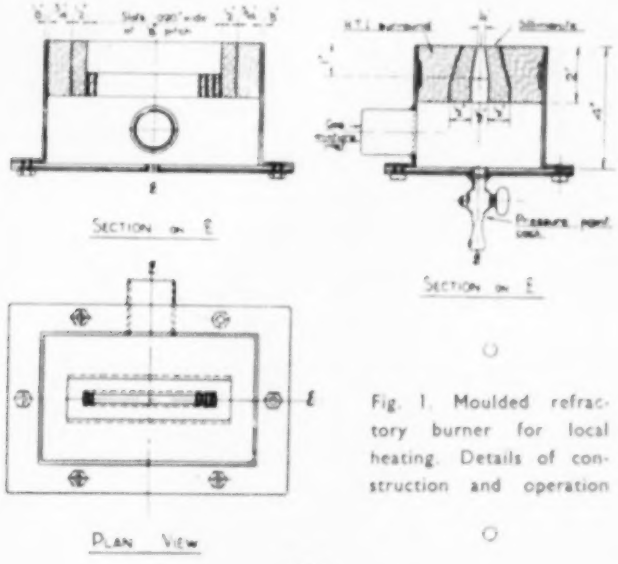

Fig. 1. Moulded refractory burner for local heating. Details of construction and operation

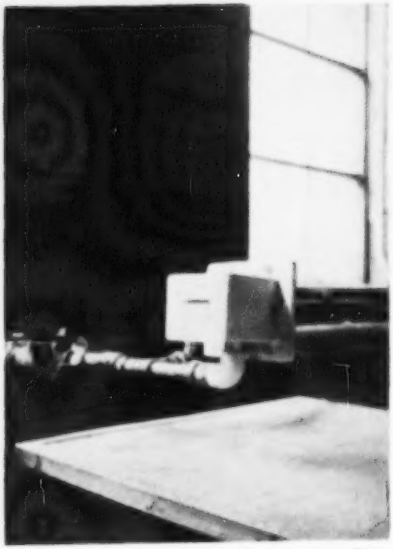

Fig. 2. General view of burner. Slot 2 in. long

work, and Papers* have been read by other members of the staff to throw considerable light on the subject.

The present work originated as the result of requests from two manufacturers who required what we may call "contoured" flames for certain fusing operations. The burner system adopted after many attempts had some very good features and though it resembles in some characteristic other forms of local heating burner, there are some aspects of its manufacture and performance that are worth attention. Accordingly, though its ultimate form is not yet decided, it is considered that the time is opportune to present an account of it to those interested in industrial burners.

It is not proposed to review other types of contact burners, descriptions of which will be found in the Papers referred to above. References will be made to them as points of comparison arise.

The factors which influence the success of a burner for local heating may be considered under the following headings:—

1. The shape, size and position of the flame.
2. The temperature of the flame and the ready reproducibility of the flame characteristics.
3. The velocity of the products of combustion as affecting the rate of heat transfer by forced convection.
4. Other factors: performance of burner, silence, flame proofness.

1. Positioning of Flame

For a flame to be so disposed to the surface or edge to be heated, that it is used to the best advantage, demands a burner designed for each particular purpose, or a burner which can be built up from a number of sections, as certain strip burners available, or a number of small units suitably placed.

Our early attempts to make a contoured burner were in the nature of converging tunnel burners fired by a drilled mixture manifold at the back. Owing to a lack of uniformity in the flame this was discarded in favour of a refractory grid, moulded for convenience with slits and not with circular holes. This was later superseded by the present design with walls moulded integral with the grid, the construction and operation of which can be followed by reference to Fig. 1.

The converging burner tunnel in which combustion takes place, is formed in a refractory block which constitutes one boundary of the mixture manifold, the other boundary being the welded steel box in which the block is rigidly retained. Air/gas mixture from a suitable mixing device passes to the tunnel proper through a series of properly proportioned slits, connecting manifold and tunnel, and there burns to give a very hot and rapid stream of products of combustion which may be accurately directed from the tunnel mouth on to the work to be heated. See Figs. 2 and 3.

Before I describe to you the operation of making such a burner system I should say that in the early days of our work on these problems our attention was drawn to the possibilities of silicon esters as bonding material for high grade refractory special shapes, and our technique of moulding preceeded concurrently with that of burner design.

* J. Palser, The Concentrated Combustion Burner, *M.I.G.A.*, November, 1945; J. F. Waight and J. Palser, Furnaceless Heating, *Industrial Gas*, March, 1947; J. F. Waight, *M.I.G.A.*, March, 1949; *Industrial Gas*, November, 1949.

The silicon esters as available commercially have the composition $Si(OC_2H_5)_4$ and they can be hydrolysed, i.e. caused to react with water to produce a silica gel which if dispersed among suitable refractory grains, can be dried and fired to give a very strong bond. The hydrolysis is effected by mixing with the ester a water-alcohol mixture, the water content of which can be varied within limits, to control the process of hydrolysis and rate of setting. Various refractories may be used, e.g. sillimanite, zirconia, alumina, etc., subject to suitable nature and size of grains. For success the grains must not be rounded but sub-angular, and a mixture of small and large should be used. We have used throughout sillimanite grains of mesh $-30 +80$ and sillimanite flour, which gives very sharp mouldings—a necessity when fire orifices are to be formed.

Moulding Operation

Let me now describe the operation of moulding. A wooden core corresponding to the desired tunnel shape is pinned mouth down, to a flat base plate and on its $\frac{1}{2}$ in. wide upper surface a series of shallow slots are cut with a hacksaw, at specified distances, to take fins to form the combustion slits. These fins are of stiff card or plastic of correct gauge and gillotined to size $\frac{1}{2}$ in. $\times 1\frac{1}{2}$ in. Over this tunnel core is clamped the burner box with back removed and with its front edge lined with H.T.I. brick, so sized as to come within $\frac{1}{2}$ in. on every side of the projected tunnel mouth. The H.T.I. is closely fitted and cemented into position and moreover retained at the sides by strips of iron pinned to the sides of the box. Into the mould thus formed the correct amount of sillimanite, ester and alcohol mixture is poured, to cover the fins to within $\frac{1}{4}$ in. of the top, vibrated to fluidise and consolidate the mass, allowed to set, dried and fired to about 700° C. After blowing out the ash and generally cleaning up, the back is sealed into position and the burner ready for use.

The size and separation of the slots to be formed in the base of the tunnel was originally founded on the consideration that with relatively large manifolds the burner should be flame proof. Limiting diameters for circular holes to prevent light back in theoretical mixtures should be of the order of 1·8 mm. = ·071 in. In point of fact, about half this width is essential. Other considerations, however, require the slot width to be ·020 in. or less, so that these burners are well within the flame proof limit.

The ratio of slot area to base of tunnel is based on the relative volumes of unburnt gas and expanded products of combustion, so that for slots of 0·020 in. width the spacing required is 7·5 to the inch (practical $\frac{1}{8}$ in. centres). The tunnel base has, from strength considerations, been kept at $\frac{1}{2}$ in. wide. The tunnel length and aperture depends on the concentration and required dimension of flame, and will be considered under the heading of velocity of products of combustion.

2. Optimum Flame Conditions

The next consideration is that of getting optimum operating conditions, i.e. of regulating air and gas to give maximum flame temperature which corresponds in a practical sense to theoretical proportions of gas and air.

For the tests and regulation of this burner we have availed ourselves freely of a device due to Brinsley and

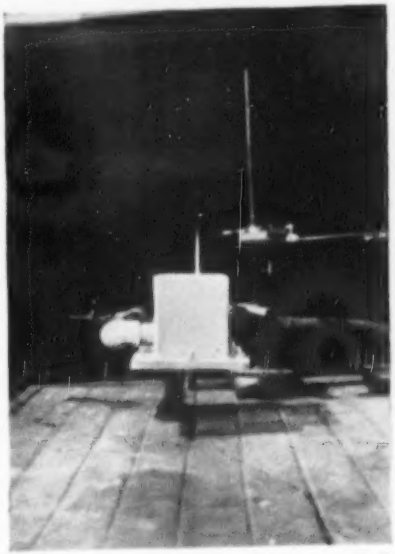

Fig. 3. Burner in operation. End elevation of flame $\frac{1}{2}$ in. wide

described in a recent Paper† to the Institution of Gas Engineers. Known as the calyx flame this device is such as to give a degree of precision to manifold burner adjustments which could not be obtained by any other means, and in fact is invaluable for both laboratory and district work. For example, reference to Table 2 shows five independent adjustments of gas rate to a standard air setting for five different venturis, fitted to the air entrainment device and indicates the exactness with which the adjustments can be made.

The calyx burner is fed by a bleed from the air-gas manifold and the mixture flame is caused to burn in its own products of combustion, with rigorous exclusion of extraneous air. If in the mixture there is air in excess of that required for combustion, then no violet "calyx" is formed at the base of the flame, but immediately on reaching theoretical mixture proportions a "calyx" appears and intensifies in colour on further enrichment with gas.

Using, as will be described later, a small water cooled tube in the flame as an indication of heat transfer, a series of tests were made with a small moulded burner with a constant air flow and variation of the gas entrained. The results are given in Table 1.

These figures show that for over aerated conditions the heat transfer is not unduly affected by excess of air. With excess of gas, however, heat transfer rapidly falls off once calyx conditions are passed. When heating a hot body, however, a different result will be obtained on account of the serious diminution in temperature difference. In practice with brazing tests it has been found that much the best results are obtained when strict attention is paid to the regulation of the burner.

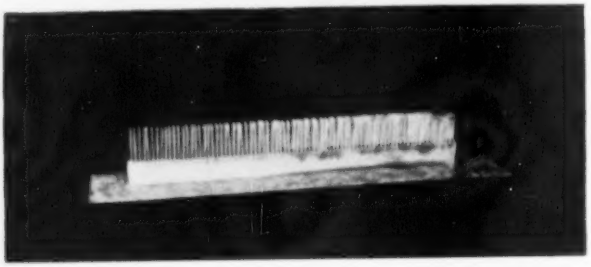

Fig. 4. Tunnel core and pins erected on base plate

For all tests, therefore, calyx adjustment was used.

The burner being of a manifold type fed by an injector, it is capable of use by entraining air at atmospheric pressure, giving constant proportioning of mixture and reproducibility of mixture and flame characteristic.

3. Maximum Velocity

Even with the hottest flame suitably disposed to the work it may still be necessary to use the maximum velocity of products of combustion, e.g. in local heating of metals where thermal conductivity is so important, speed of heating is essential. Or again it may be necessary to make the best use of available air pressure. We must, therefore, examine the problem of producing maximum velocity of pro-

TABLE 1

Aeration condition	Gas flow c. ft. per hr.	B.Th.U. per hr. measured	B.Th.U. per sq. ft. per hr. (thous.)	B.Th.U. (thous.) per sq. ft. per hr. per c. ft. of gas
Over aerated, no calyx	66·5	875	312	4·7
Ditto	70·6	992	354	5·0
Ditto	75·9	1,061	379	5·0
Faint calyx	78·5	1,095	391	5·0
Pronounced calyx	80·7	1,073	383	4·75
Ditto	81·5	940	334	4·1
Ditto	88·5	955	340	3·84

† Brinsley. June Research Meeting, Inst. Gas E., *Gas Heat in Industry*, August, 1949.

TABLE 2

TESTS TO DETERMINE OPTIMUM DIAMETER OF VENTURI FOR USE WITH A GIVEN BURNER AND CORRESPONDING PRESSURE AND FLOW RELATIONS

Air jet dia. in. d	Venturi throat dia. in. D	Ratio $\frac{D}{d}$	Gas pressure in. w.g.	Manifold pressure in. w.g.	Gas rate c. ft. per hr	Suction at point of entrainment	Condition gas and air full on
241	·281	1·17	3	7·7	126	− 6·9	overgased
	·312	1·29	3	8·4	131	−12·4	"
	·336	1·39	3	8·4	132	−12·5	"
	·360	1·49	3	8·2	128	− 9·75	"
	·385	1·60	3	8·0	127	− 8·05	"
	·281	1·17	0	8·0	127	− 6·9	"
281	·281	1·00	3	12·4	164	− 1·5	"
	·312	1·11	3	13·15	171	− 4·4	"
	·336	1·20	3	13·15	171	− 5·2	"
	·360	1·28	3	13·0	169	− 4·65	"
	·385	1·37	3	12·95	168	− 3·7	"
	·385	1·37	0	12·95	168	− 3·7	"
306	·281	0·92	3	14·4	170	+ 2·4	no calyx
	·312	1·02	3	15·3	188	+ 0·5	overgased
	·336	1·10	3	16·0	193	− 2·1	"
	·360	1·18	3	15·9	192	− 1·6	"
	·385	1·26	3	15·6	189	− 0·9	"
	·336	1·05	3	16·7	199	+ 1·5	"
	·360	1·12	3	17·0	202	+ 1·3	"
	·385	1·20	3	17·0	200	+ 0·5	"

Burner dimensions:
Mouth 3 in. × $\frac{1}{4}$ in.
Slots 17 × ·024 in. × $\frac{1}{4}$ in.
of area 0·204 sq. in.

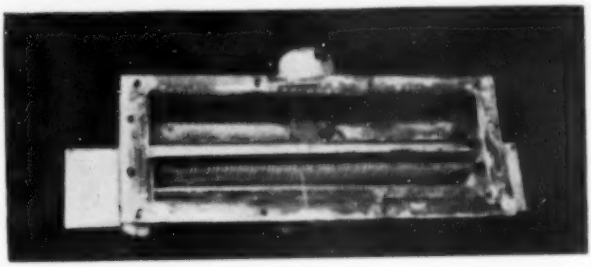

Fig. 5. Box with H.T.I. lining fastened over core, and fins "dressed"

ducts of combustion on to the work. This velocity will all have its origin in the energy of the air jet which energy will appear partly as static pressure in the manifold and static pressure at the base of the tunnel which latter pressure accelerates the gases towards the mouth when the tunnel is convergent. The conditions for the successful accomplishment of this energy conversion have been laid down in a Paper already referred to, and the results given form a very satisfactory confirmation. I am giving in Table 2 a number of sections of a complete test of a burner system which could be fitted with five sizes of venturi and in which the air jet was increased progressively in stages.

The following points are of importance:—

1. In each series of tests venturi No. 3 gives the maximum manifold pressure and maximum gas rate corresponding to calyx conditions. For this optimum size of venturi the ratio of throat area to port area was 0·435 in.
2. As the size of this jet is increased and the ratio of the diameter of the venturi to that of the air jet approaches 1·1 so maximum manifold pressure and gas flow are developed.
3. Within the size limits laid down above automatic proportioning due to governing to atmospheric pressure is possible.
4. It is worthy of note that the maximum manifold pressure corresponding to 40·8 in. w.g., air pressure is 17·0 in. w.g., which corresponds to 42 per cent. conversion. This serves as a guide to the efficiency of energy conversion.

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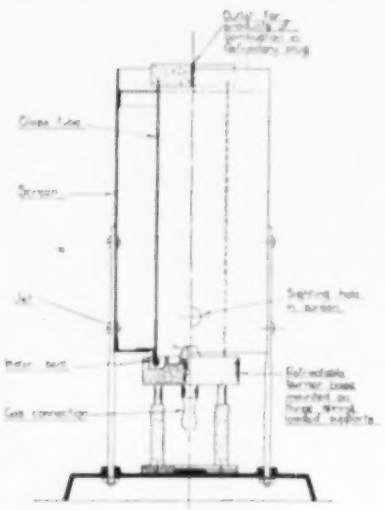

Fig. 6. Theoretical air requirement burner

These data lay down, for our gas, the approximate proportions of an injection system and burner, but are subject to certain limitations.

The effective aperture of the burner is not that of the slots alone for the resistance of the tunnel beyond these slots also has an effect on restricting the escape from the manifold. In fact the pressure developed at the base of the tunnel is fairly considerable, as the following figures for a tunnel of taper 21° (included angle) would show.

Air pressure, in. w.g.	6·8	13·9	26·2	56·1	111·2
Manifold pressure, in. w.g.	3·5	5·6	9·7	17·7	30·4
Tunnel pressure, in. w.g.	0·5	0·8	2·1	4·3	7·7

From these figures it would follow that the ratio of possible discharge without tunnel, to that obtained with the tunnel, is 1 to 0·93 for the lower air pressures. In other words for this very convergent tunnel the tunnel is equivalent to a reduction in grid size of 7-13 per cent. according to the air pressure. For most purposes, therefore, this correction can be neglected.

It might be noted at this point that the discharge coefficient of the slots varies from 0·37 to 0·05 which is the result of a temperature effect, the mixture tending to heat up at low rates of throughput.

(To be continued)

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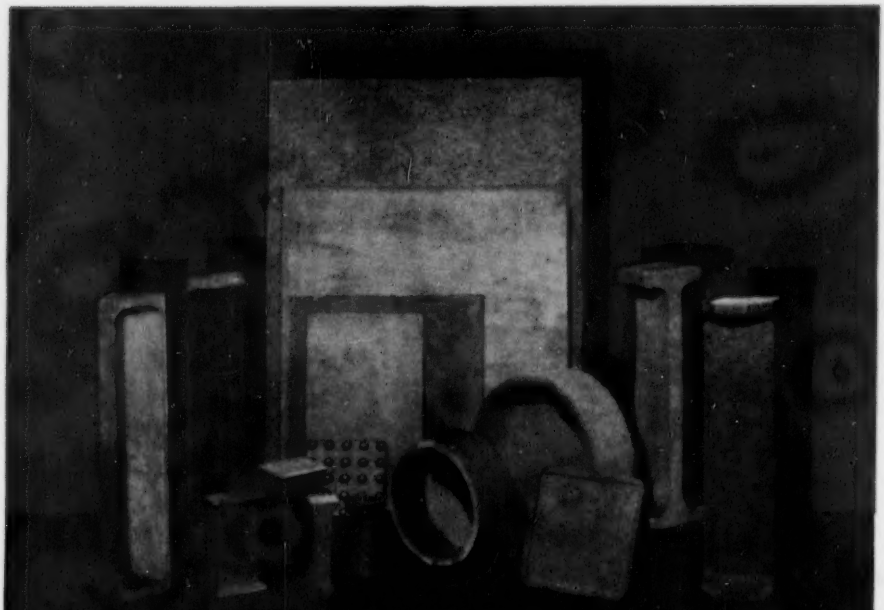

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